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STARCH GELS

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Starch gels impart to food materials and food mixtures characteristics peculiar to the kind of starch present. For example, baked flour mixtures owe their properties to hydrated, heated starch as well as to the other constituents, and in cooked potato the starch determines very largely the texture and quality found there. Starch of some kind or another "thickens" the sauces, puddings and fillings which we eat daily; the choice of a starch for thickening purposes depends upon the flavor which the different starches possess and also upon the physical character of the paste or gel produced. The starches encountered most often are those of cereals and of roots, of which six kinds furnished material for observation in this study.

The character of the gel that a starch will yield and the conditions under which the gel forms, serve as means of observing the behavior of different starches. There are no satisfactory methods of measuring the stiffness of starch gels. Viscosity measurements can be applied to thin pastes but not to heavy ones containing 4% or more of starch, and plastometric means have not yet been developed for use with material of this structure. Photographs have served in this study to give permanent records of differences in physical appearance which could otherwise be described but inadequately. The pastes photographed contained 5% starch, in which concentration many kinds of starches will form gels capable of retaining the shape of a mold and therefore of being photographed. The outline of the gel indicated much of its character, though differences were noted in degree of opaqueness, tenderness and freedom from gumminess. Amounts of sucrose equal to those sometimes used in sweetening starch puddings were added to pastes, and the diminution of gel strength thereby produced was noted.

The records obtained in our study, of temperatures to which

pastes had to be heated before gelation was possible, contribute something to the present information on gelatinization temperatures of starches. The subject of gelatinization has occupied many investigators, the details of whose measurements have already been reviewed several times. (Reichert, 1913; Alsberg and Rask, 1924.)

Methods used have consisted of noting microscopic changes in the appearance of the granules, of observing temperatures at which translucency is altered, and of studying changes in viscosity of the paste. Gelatinization temperature has, in this study, been noted in connection with the ability of the cooled paste to form a gel. Our results are in agreement with the statement by Alsberg (1926) that the gelatinization change is continuous over a range of temperature. We have found maximum gelation to occur only after the paste has been heated to a temperature of 90° or above.

The syneresis of gels of varying starch concentration has been measured by Chapman and Buchanan (1930) in corn, wheat, rice and potato starch gels. They state that neither the rate nor the length of the period of heating the suspension affects rigidity or the amount of syneresis in the resulting gels. Hence all their pastes were heated quickly to boiling over a flame and poured out at once. It is not possible to say whether our gels, prepared somewhat differently, were similar in properties to the ones with which Chapman and Buchanan worked, because they confine their measurements to the amount of syneresis and offer no description of the gels' appearance.

Method of Study

Because starch thickening agents are used in the household in only fairly pure form, no attempt was made to purify the samples for these experiments. The cornstarch was a well-known brand of culinary type and the wheat, rice, potato, arrowroot and cassava starches were purchased through a laboratory supply house. In order that results might be interpreted correctly, analyses were made for moisture, ash and nitrogen, the results of which will be found in Table I. No significant amount of nitrogen was found in

TABLE I

Analysis of the Starches Used

	Moisture %	Ash %	Nitrogen %
Corn	11.30	0.20	0.032
Wheat	10.25	0.13	0.026
Rice	10.80	0.70	0.071
Potato	14.29	0.35	0.049
Arrowroot	13.59	0.28	0.029
Cassava	10.63	0.15	0.012

any starch; the moisture was about what would be expected in products marketed in paper packages. Ash content indicated that the starches were not pure, but they were so nearly so that differences in gel characteristics could be attributed to the starch component of the only fairly pure material. These observations will be repeated and extended later with purified instead of commercial starches.

One hundred grams of a 5% by weight suspension of starch in water was heated in a 150 cc. test tube which was immersed to a depth below the level of the suspension in a mechanically stirred water bath. The bath consisted of distilled water in a beaker behind which a strong light was placed. The light shining through it made changes in appearance of the contents of the test tube easily discernible. The deep, slender column of starch suspension insured uniform penetration of heat. By means of a glass rod bent to a paddle the starch was stirred occasionally by hand until the stage had been passed where granules were apt to settle to the bottom. Thermometers in the bath and in the tube indicated that there was a uniform difference in temperature between the two of 5° C. throughout the heating period until the bath reached 100°, after which 22 min. more were required to bring the temperature of the starch paste to 99.5° C. the maximum obtainable inside the test tube. At this rate of heating, the starch paste reached a temperature of 90° in about 38 min. The time and temperature intervals are given in the graph (Figure 1).

The tube of starch was removed from the bath after the desired interval of heating and the slight loss by evaporation was adjusted by the addition of water. The paste was viscous but fluid while hot; it was poured into small porcelain crucibles holding 10 g. of paste. Or, in some cases, only a part of the contents of the test tube were poured out and the heating of the remainder was continued for a time after which molds were filled again. At the end of 24 hours the gels were turned out of the molds onto watch crystals and examined for general appearance and firmness. One intact mold of each lot was reserved for photographing. The gels formed in less time than 24 hours but it was convenient to examine all samples one day after they were made.

In certain series sucrose was added to the cold starch suspension and the whole heated together. When 10, 30 and 60 g. of sucrose were added to the 100 g. of starch paste, the corresponding samples were said to contain 10, 30 and 60% of sucrose. It was desired that the ratio of starch to water be kept constant whether or not sucrose was present.

Discussion

Heating temperature required for gelation.—In the course of the gradual heating of the tube of starch suspension there occurred a continuous but slight diminution in opacity. There was visible, however, a quite sudden increase in translucency at a temperature which was specific for each starch. The temperature at which this change occurred was not a sharp one but ranged over 1 or 2 de-

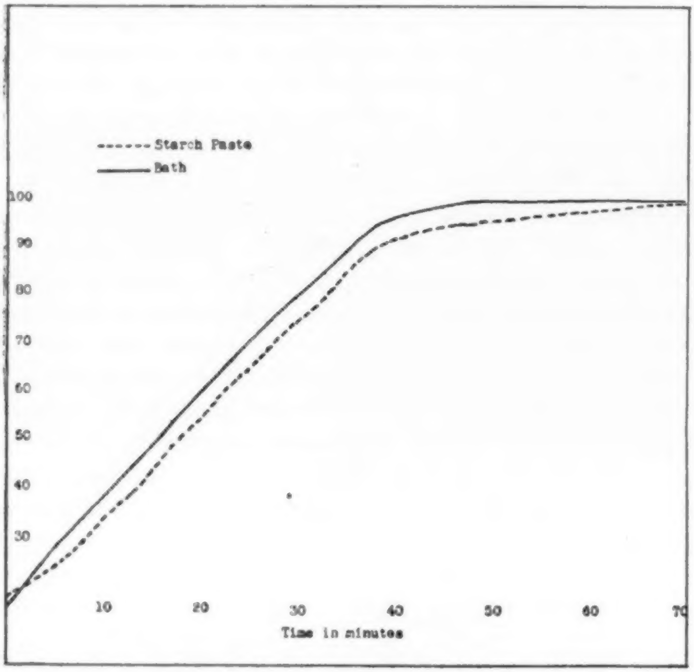

Fig. 1. Rate of Rise in Temperature of Starch Paste and Bath

grees. The paste seemed to have reached its maximum translucency at this temperature; heating either for a longer time or to a higher temperature made but slight difference in its color. This temperature corresponds to what some have called "gelatinization temperature" and for each kind of starch in 5% concentration [1] was:

Corn	86 to 87°C.	Potato	69 to 70°C.
Wheat	87 to 88°	Arrowroot	79 to 80°
Rice	84 to 85°	Cassava	74 to 75°

The change in translucency at what is called here the gelatinization temperature was accompanied by decided swelling of the

[1] It is likely that the temperature of gelatinization as evidenced by changes in translucency varies with the concentration of starch.

starch granule as shown by microscopic examination, and there was also apparently a change in viscosity under these conditions, though no measurements on the latter are being reported at this time. This temperature was insufficient, however, to permit maximum swelling of the granules, without which seemingly a gel will not form. Samples were poured into molds at the temperatures given above for each starch; the cooled pastes showed evidence of having thickened somewhat at this temperature (bottom row, Plate I) but the gel was weak, granular and showed much syneresis. No evidence of gelation appeared in pastes which had been heated to temperatures 1° or 2° below those given.

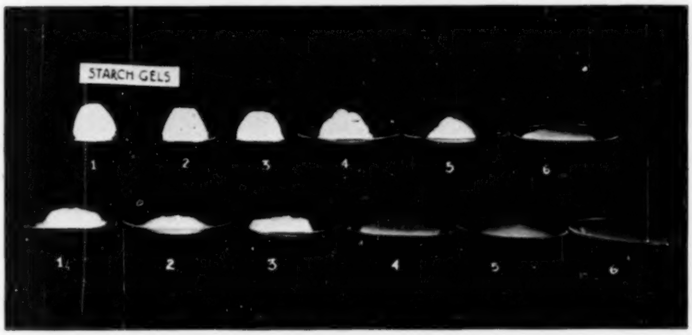

Plate I. Gels of Six Kinds of Starch

1. Corn; 2. Wheat; 3. Rice; 4. Potato; 5. Arrowroot; 6. Cassava.
Above: All pastes had been heated to 99.5° C.
Below: Pastes had been heated to 87°, 88°, 85°, 70°, 80° and 75°, respectively.
(Visible changes in translucency of the pastes occurred at these temperatures.)

Continuing the heating to 99.5° C. gave the three very well-formed cereal starch gels of the top row in Plate I and the soft or quite fluid gels of the root starches also pictured in the top row. Of the three cereal starch gels, the rice was most translucent and most tender as it was cut; cornstarch gave the firmest gel and was chalky white in color even though its hot paste had been a translucent blue. Wheat starch gave results intermediate in value. The potato starch paste was ropy and almost water-clear; the cold gel was quite transparent, too gummy to leave the mold well and in all a poorly formed gel. Arrowroot gave a still more transparent and softer gel. The cassava starch paste was only a viscous fluid even when heated to 99.5°.

If the maximum strength of a gel is desired in a starch, its paste must be heated beyond the temperature at which its translucency suddenly increases. This result suggested that perhaps long continued heating at the gelatinization temperature might

bring about maximum gelation. Each starch was therefore heated in turn for 15 and 30 minutes at its gelatinization temperature; this improved gelation somewhat but did not yield a gel which even approached in firmness the one which had been heated to 90° and removed immediately. Heating the paste to 90°, 95° and 99.5° gave gels indistinguishably alike. This manner of finding the conditions for maximum gel strength was used with each starch in turn with the same general result. Only the wheat starch is so represented in the plates. (Plate II.)

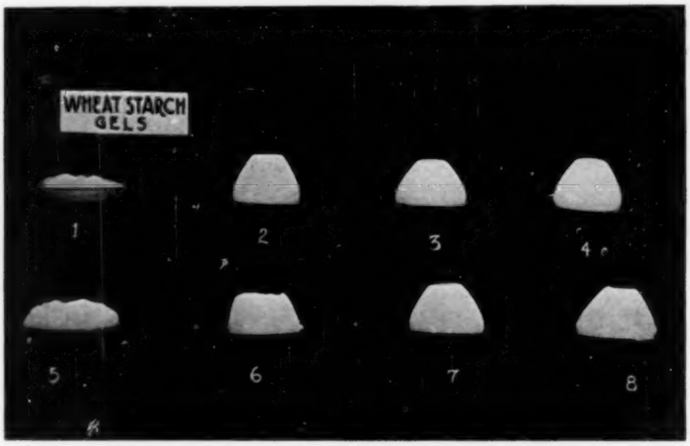

Plate II. Effect upon Gel Formation of Time and Temperature of Heating

1. Paste was heated to 88° C.
2. Paste was heated to 90° C.
3. Paste was heated to 95° C.
4. Paste was heated to 99.5° C.
5. Heating continued at 88° C. for 15 min.
6. Heating continued at 88° C. for 30 min.
7. Heating continued at 99.5°C. for 15 min.
8. Heating continued at 99.5° C. for 30 min.

Most starch mixtures probably reach a temperature of 95° to 100° in the course of ordinary cooking. Forty or more records on the inner temperature of baked potatoes have given 100° to 104° as the one for "doneness"; at an inner temperature of 97° the potato seemed still underdone. Biscuits, muffins and butter cake reached a temperature of 100°, yeast bread 98° and even angel food cake, containing as it does large amounts of easily over-coagulable egg white, has been found to have attained an inner temperature of 97°, 98°, 99° and 100° in four different bakings.[2] Other factors than the gelation of the starch of course contribute to "doneness" in the above products but there is little likelihood that incomplete gel formation occurs commonly, since it has just been shown that a temperature lying between 87° and 90° is sufficient for complete

[2] Unpublished results by Woodruff.

Plate III. Effect of Increasing Sucrose Concentration upon Gel Formation

1. Sucrose none
2. Sucrose 10 percent
3. Sucrose 30 percent
4. Sucrose 50 percent

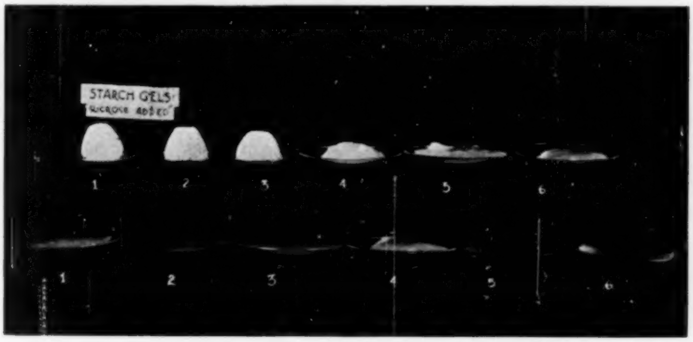

Plate IV. Effect of Sucrose upon Gels of Six Starches

1. Corn; 2. Wheat; 3. Rice; 4. Potato; 5. Arrowroot; 6. Cassava
Above: Gels containing 30 per cent sucrose, heated to 99.5° C.
Below: Gels containing 60 per cent sucrose, heated to 99.5° C.

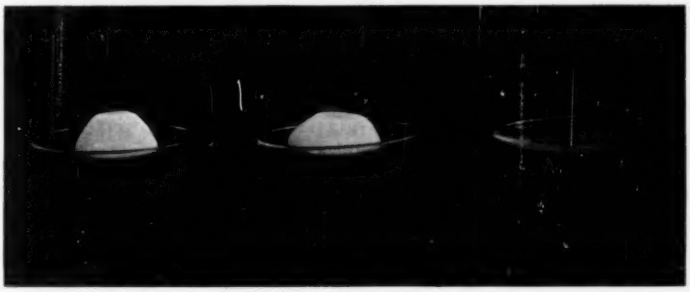

Plate V. Effect of Reducing the Starch Concentration per Unit of Volume by Adding Sucrose and by Adding Water

Left: Contains 5 grams of wheat starch and 95 grams of water.
Center: Contains 5 grams of wheat starch and 132 grams of water.
Right: Contains 5 grams of wheat starch, 95 grams of water and 60 grams of sucrose. The volumes of center and right were the same.

gelation of wheat and corn starches. In rice the temperature lies between 85° and 90° and in potato between 70° and 80°. Arrowroot and cassava formed very poor gels which were little improved by heating to a higher temperature.

Effect of sucrose upon gels.—The failure of starch-thickened fillings to gel in the presence of large amounts of sugar is not infrequently noted. In studying the conditions under which such an effect is produced, additions of different quantities of sucrose were made to pastes, all of which were heated to 99.5° and the resulting gels photographed. Gels containing successively 10, 30 and 50% sucrose showed increasing transparency and tenderness but were well-formed in the three cereal starches. When 60% sugar was added, however, a viscous, syrupy mass resulted but no gel. Plate III, illustrating wheat starch, shows that there is very little outward effect upon the starch of amounts of sucrose up to 50%. Plate IV pictures the rigidity of gel structures of the six starches in the presence of each 30 and 60% sucrose. The three root starches had formed very weak gels even in the absence of sugar; when so little as 10% sucrose was added to their pastes a noticeable softening occurred and 30% flattened out the gel considerably. A syrup was the result when 60% sugar was used with the root starches, as was also the case in the cereal starch pastes.

The volume of a starch-sugar paste containing 5 g. of starch, 95 g. of water and 60 g. of sucrose was 132 cc., whereas the volume of the same amounts of starch and water was approximately 100 cc. The increase in volume had reduced the starch from 5 to 3.8% on the basis of volume. Such a reduction in the ratio of starch to volume would account for some diminution in gel strength but not for the progressive change in color and translucency which was noted as more and more sugar was added. There is evidence in the series of wheat starch gels in Plate V that the sucrose did have a specific effect upon gelation. Photographed there is the syrupy fluid of the paste containing 60% sucrose and a tender but well-formed gel obtained when a starch-water paste was diluted with water to 132 cc., the volume of the sugar-containing one. For purposes of comparison, a gel containing 5 g. of wheat starch and 95 g. of water is also shown in Plate V.

The mechanism of this action by sucrose can only be speculated upon in the light of the present findings. It is possible that the presence of large amounts of sucrose prevents the starch granules from imbibing the water needed for their swelling. The amounts of sucrose employed here are none of them beyond the limits of

what is used in cooked starch mixtures. The cause of the behavior of sucrose is being studied now by other means.

Summary

When starch-water pastes containing 5% of either corn, wheat, rice, potato, arrowroot or cassava starches were heated only to the temperatures at which the different ones exhibited marked changes in translucency, the cooled pastes did not form gels strong enough to retain the shape of a mold. Maximum gel strength was obtained in each starch at a temperature of 90° or higher. The cereal starch gels were well-formed and had clearly defined outline; root starches gave poorly-formed gels. Photographs constituted a permanent record of the appearance of these gels.

Maximum gelation of starch very probably occurs in baked flour mixtures, in cooked potatoes and in flour-thickened sauces. The final inner temperature of such products has in many cases been observed to be at or near 100° C.

The presence of sucrose in amounts as great as 60% of the weight of the starch paste reduced the mass to a viscous syrup. A starch-water paste of the same volume did not behave as did the starch-sugar-water one. This effect of sucrose is being studied further.

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Chapman, O. W., and Buchanan, J. H.
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REPORT OF THE COMMITTEE ON METHODS OF TESTING CAKE AND BISCUIT FLOURS

MARY M. BROOKE, Chairman

(Read at the Convention, May, 1931)

The following recommendations were adopted by the Committee as a whole, on the evening of May 26, after the reading of the reports of the subcommitteemen on the morning of May 26.

Committee Recommendations

I. Recommendation of the Chairman

1. That the Committee be enlarged and divided into several sub-committees or that several committees be appointed to study the problems relating to the testing of cake and cracker flours, as the problems in this field of cereal chemistry are becoming too involved and numerous for any one committee to handle efficiently.

II. General Recommendations

1. That a definite study be undertaken of the effect of chlorine bleach on soft wheat flours.

2. That the committee, as a whole, review different cake score cards for the purpose of determining those of merit which could be given further study by designated committee members.

3. That consideration be given to mixing cake batter to a definite specific gravity.

III. Specific Recommendations of Subcommitteemen

1. That further study be made relative to aliquoting the creamed sugar-shortening mass.

2. That the use of a larger batch, to permit the taking of sufficient batter without scraping the bowl, be studied.

3. That the baking of one or several small cake batters in the same pan, separated by temporary partitions, be studied.

4. That single stage mixing be adopted for the standard cake baking test for the reason that it eliminates uncontrollable variables.

5. That creaming the sugar and shortening mass to a definite specific gravity rather than for a definite time is to be recommended when the creaming method is used in making the standard cake baking test.

6. That the study of viscosity in reference to the standard cake baking test be abandoned.

7. That viscosity be studied as a separate factor in the testing of cake flours.

Report of Subcommittee on Methods of Scoring

R. A. Barackman

No changes have been made in the score card since last year. Changes could be made in the values assigned to the individual scores, but the committee would be no further ahead.

The utility of a score card is chiefly a matter of personal opinion and preference, and until we are able to secure a more general expression on the design of the card it does not seem that an all purpose score card is possible at the present time. However, in order to make progress, the committee as a whole, recommended the following reconstructed score card be used for future study.

SCORE CARD

Perfect Score	Points	
		A. EXTERNAL
10		1. Symmetry (Receded, rounded, excessive)
15		2. Volume
5		3. Crust
		Sugariness
		B. INTERNAL
30		1. Texture
	15	Tenderness
	15	Silkiness
25		2. Grain—Size and uniformity of cell structure
15		3. Color
100		

EXPLANATION OF TERMS

1. **Symmetry:** The curvature of the upper crust of a cake will indicate the strength of a flour.

2. **Volume:** is related to symmetry, but assuming equivalent conditions of air incorporation during creaming and beating and equivalent extent of leavening reaction, volume will vary with the strength of flour.

3. **Crust:** The thickness and tenderness of the crust as well as sugariness and color will in a large measure depend upon the abilities of the operator.

4. **Texture:** Tenderness is an indication that a flour will produce a crumb which is resilient and will not crumble. A silky crumb is dependent upon the granulation of the flour. A moist crumb, not soggy or dry, indicates a desirable quality in a flour to retain moisture.

5. **Grain:** The uniformity of cell structure is related to the gluten quality of a flour.

Tunnels indicate improper mixing.

Size of cells and thickness of cell walls are a criterion of the ability of the flour gluten to stretch and to retain the structure upon baking out.

6. **Color** is of minor importance since most flours are used in cakes colored by other ingredients.

The above score card is very easily adaptable to commercial use. The opinion of collaborators was that the flavor of cakes should be weighted the same as internal appearance. By considering a perfect score of 200, flavor could receive 65 points, leaving 35 points for odor, icing and other properties of commercial interest.

Creaming for a Definite Time Compared with Creaming to a Definite Specific Gravity

G. L. Alexander

The first step in preparing the batter for our white test cake consists in creaming the sugar and shortening together until they form a smooth emulsion of the maximum volume and lightness. We recognize that the character of this creamed mass has a most important bearing on the scoring value of the finished cake, and we would hardly expect comparative results in our cake tests unless the creamed emulsion were always brought to the same degree of lightness.

The proper creaming temperature was fixed last year by Fisher (1930) at close to 73° F. The type of mixer to be used was also specified, as well as the size of sugar granulations. No exact specifications are set for the shortening, although it is assumed that one of the hydrogenated types should be used. Slight variations in the nature of sugar and shortening will be encountered, and our mixers will vary in efficiency even though they are of the same size and type. The present procedure directs us to cream for 1 min. at low speed, and then for 10 min. at medium speed, but as these directions are inflexible and do not consider the variables just mentioned, they do not insure uniformity in the emulsion.

About a year ago a long series of creaming and mixing methods were described by Glabau in a trade journal. This series was very thorough, and many of the experiments were checked by others of close similarity. In summarizing this work, he says, "As far as mixing is concerned, the matter of producing a mixture of definite specific gravity seems to be most important, irrespective of how the ingredients are put together." Again recently, at a meeting of the Society of Bakery Engineers, a paper was read by an expert in which he quoted from his experience in making white cakes. He also said that there is a direct relation between the specific gravity of the batter and the value of the finished cake.

It is not the object, at this time, in view of the contemplated complete revision of our mixing procedure, to give data showing the optimum specific gravity for the cream emulsion used in the test cake. It appears very probable, however, that the mixing and creaming variables will be reduced if the emulsion is built up to a definite specific gravity instead of merely creamed for a definite time. The method used to arrive at the creaming time required to

produce this emulsion, under the room conditions and with the ingredients at hand on any particular day, is as follows:

The sugar and shortening, at 70° F., are creamed for 8 min., and then a portion of the emulsion is pressed lightly into a shallow dish (55 mm. top diameter x 15 mm. high), the weight of which is known. The weight of the emulsion is recorded, and the procedure is repeated at 2 min. intervals until the weight of the emulsion does not decrease any further. The creaming time required to produce the emulsion sample of lowest weight is the time used is the series of tests about to be made. By referring the weights of the emulsion samples to the weight of an equal volume of water the specific gravity can be obtained and a useful curve can be plotted, using time intervals and specific gravity figures, to show the progress of the creaming action.

By using a definite specific gravity for our creaming endpoint we can place this part of our cake testing method on a more accurate and scientific basis. It is also recommended that consideration be given to mixing the cake batter to a definite specific gravity.

Literature Cited

Fisher, V. E.
1930 Report of committee on testing cake and biscuit flours. Effect of temperature on the dough and its influence on the standard baking test. Cereal Chem., **7**: 367.

Report on Methods of Incorporating Ingredients in Cake Batters

L. H. Bailey

In continuation of this work, the sub-committee this year has made a collaborative study of the "creaming" method in comparison with the "single stage" method of mixing.

In the creaming method, designated as Method I, the sugar and shortening were mixed at low speed in a Hobart mixer for 1 min., the sides of the bowl were scraped and the mixing continued for 10 min. at medium speed, when the bowl was again scraped and the mixing continued at low speed while the sifted dry ingredients were gradually added alternately with the egg white which had been suspended in 150 cc. of water one-half hour previously. The bowl was again scraped and the mixing continued for 2 min. at medium speed.

The batter was divided equally into two pans, one of which was placed in the oven immediately and designated as "A," and the other one allowed to stand at room temperature for 30 min. and then baked. The latter was designated as "B."

In the "single stage" method, called Method II, all the ingred-

ients except the leavening agents or one of them, as in this case the cream of tartar, were added at one time. The mixing was started at low speed so as not to lose any of the material. After 1 min. the bowl was scraped and mixing continued at medium speed for 10 min. Again the bowl was scraped and the leavening, or, in this case, the cream of tartar, was added and the mixing continued for 2 min. at medium speed, when the batter was divided into "A" and "B" and treated the same as in the creaming method.

Ten collaborators who were known to be interested in this work, and who have had extended experience in cake making, assisted in this study. These collaborators were asked to use their own flour and equipment. They were furnished two formulas. Formula No. 1 is the same as published in Cereal Chemistry, **6:** 313 changing only the water to 230 cc. instead of 250 cc. and Formula No. 2 is a modification of a so-called commercial pound cake using egg white.

The formulas follow:

Formula No. 1

Hydrogenated shortening	75.0 g.
Sugar (finely granulated)	175.0 g.
Flour (soft wheat)	225.0 g.
Dry skim milk	15.0 g.
Albumin	5.0 g.
Salt	3.0 g.
Cream of Tartar	6.0 g.
Bicarbonate of soda	3.0 g.
Water	230.0 cc.

Formula No. 2

Hydrogenated shortening	103.0 g.
Sugar (finely granulated)	203.5 g.
Flour (soft wheat)	225.0 g.
Dry skim milk	9.5 g.
Albumin	15.5 g.
Salt	3.3 g.
Cream of tartar	4.0 g.
Bicarbonate of soda	2.0 g.
Water	170.0 cc.

Each collaborator was asked to bake two cakes by each of the two methods of adding ingredients, with each of the two formulas (or make 8 cakes) and to report the results as scored by the score card published in Cereal Chemistry, **7:** 366, (1930).

These results are shown in Table I.

In this table the total score for each cake is given as well as the average score for each pair of cakes made from the same batter. The grand average (shown at the bottom of the table) is the average of all the scores made by the two methods with each of the two formulas. These results indicate that better cakes were made by the "single stage" method than by the creaming method, although there are individual instances where the reverse is true.

Comments of Collaborators

Elise C. Shover.—Formula 1, Method 2, B, had undermixed streaks in cake. Oven too cool. Cakes did not bake fast enough. Batch slightly small for mixer used.

Edward E. Smith.—This scoring does not give a picture of the results. Method 2 gave a slightly larger cake than Method 1, but it was at a pronounced sacrifice of internal quality.

TABLE I

Collaborative Baking Tests—Ten Operators—One Flour Each

	Formula No. 1				Formula No. 2			
	Method 1		Method 2		Method 1		Method 2	
	A	B	A	B	A	B	A	B
Miss Elise C. Shover								
New South Bakery	83.0	87.0	83.0	87.0	84.0	83.0	87.0	85.0
Atlanta, Ga.	85.0		85.0		83.5		86.0	
E. E. Smith								
F. W. Stock & Sons	84.0	80.0	84.0	80.0	81.0	78.0	83.0	80.0
Hillsdale, Mich.	82.0		82.0		79.5		81.5	
R. A. Barackman								
Victor Chemical Works	59.0	59.8	53.8	55.1	87.2	87.1	84.0	84.7
Chicago Heights, Ill.	59.4		54.5		87.2		84.4	
Miss Pearl Brown								
Perfection Biscuit Company	82.8	89.0	93.5	92.5	75.5	78.3	82.0	81.5
Ft. Wayne, Ind.	85.9		93.0		76.9		81.8	
Elizabeth McKim								
Provident Chemical Works	100.0*	99.1	100.5	100.1	100.4	100.0	101.0	100.6
St. Louis, Mo.	99.6		100.3		100.2		100.8	
W. H. Croot								
Trent Institute	75.6	76.4	77.8	78.4	84.8	83.5	83.5	83.0
Guelph, Canada	76.0		78.1		84.2		83.3	
George L. Alexander								
Commercial Milling Co.	88.0	89.0	89.0	88.0	84.0	83.5	84.0	85.0
Detroit, Mich.	88.5		88.5		83.8		84.5	
H. S. Mitchell								
Swift & Company	83.6	87.7	94.8	94.5	73.8	74.3	95.8	92.3
Chicago, Illinois	85.7		94.7		74.1		94.1	
Mrs. Laura K. Track								
Royal Baking Powder Co.	81.3	84.7	89.5	92.4	84.1	87.7	92.6	92.7
Brooklyn, New York	82.0		91.0		85.9		92.7	
L. H. Bailey								
U. S. Dept. of Agriculture	81.0	83.6	83.6	82.5	84.5	82.8	81.5	80.3
Washington, D. C.	82.3		83.1		83.7		80.9	
Grand Average	82.6		85.0		83.9		87.0	

*Standard

R. A. Barackman.—Method 2 using Formula 1 when compared with Method 1 resulted in cakes having a looser crust, a more dense doughy area, smaller cells and thicker cell walls. Solution of sugar was not in evidence in cakes made by Method 2.

Method 2 using Formula 2 and comparing with Method 1 resulted in cakes having somewhat looser crusts, although in general Formula 2 cakes had crusts attached firmly to the body of the cake. Method 2 cakes had crusts which sagged toward the

middle and in consequence the symmetry score was marked down. The cell structure of cakes made by Method 2, Formula 2 as compared to those made by Method 1 was more uniform; the cells were decidedly smaller with thicker walls.

Pearl Brown.—There really was but little difference in the cakes left out for a half hour. Cakes baked by Formula 2 as a whole group were not so good as those made by Formula 1.

H. V. Moss, reporting for Elizabeth McKim.—There was more difference in cakes from Method 1 and 2 with Formula 1 than with Formula 2. Formula 1, Method 2, gave a decidedly poorer color. There was practically no difference in the cakes baked immediately and those that stood one-half hour before baking.

W. H. Croot.—Mixture No. 1 tended to be slack. There was a streak or heavy portion tending to slight sogginess in the bottom portion of the loaf which did not entirely bake out. Mixture No. 2 was lightly stiff. The cake had very good volume and internal properties, but was flat on top.

George L. Alexander.—According to the scores registered by the cakes the critical factor was the formula and not the method of mixing, as the results from each formula came very close together.

H. S. Mitchell.—Our results indicate that for the formulas used, the single stage method is superior. We do not consider, however, that the results of the tests made are indicative of what can be accomplished with the sugar-shortening method of mixing cake.

Laura K. Track made no comments on methods of mixing, but allowed her results to speak for themselves.

L. H. Bailey.—With the particular flour used, the score was slightly higher for Method 2, than for Method 1, with Formula 1, while the reverse is true for Formula 2. Similar results were obtained by other collaborators.

Each collaborator was asked to send a sample of the flour used in his collaborative work to the writer of this report. These flours were baked on the same day and under as nearly the same conditions as possible. Formula 1, Method 1 was used with all ten flours one day and Formula 1, Method 2 another day, and so on until both methods had been used with both formulas.

These results are shown in Table II.

In this table are given the individual scores and the average score of each pair of cakes made from the same batter, as well as the grand average, which is the average of all results by each

method and each formula. In addition there are shown the chemical analyses of the flours.

It will be noted that in the grand average, the single stage method, (Method 2), Formula 1 scores slightly higher than the creaming method, (Method 1), but with Formula 2 the reverse is shown. With other formulas, we have shown higher scores for Method 2 than for Method 1.

TABLE II

Baking Tests on Collaborative Flours—One Operator—Ten Flours

Sample	Formula 1				Formula 2				Analyses		
	Method 1		Method 2		Method 1		Method 2		Moisture	Ash	Nitrogen
No.	A	B	A	B	A	B	A	B	%	%	%
601	81.0	84.0	85.1	85.2	84.5	82.4	82.0	81.7	10.75	0.49	1.73
	82.5		85.2		83.5		81.9				
602	86.9	87.0	88.4	88.1	83.7	84.1	83.4	82.5	9.99	0.34	1.51
	87.0		88.3		83.9		83.0				
603	81.7	82.4	84.5	84.5	84.9	81.3	81.8	81.1	9.98	0.36	1.51
	82.1		84.5		83.1		81.5				
604	78.5	78.2	84.8	85.5	82.5	82.9	82.1	82.3	10.42	0.43	1.61
	78.4		85.2		82.7		82.2				
605	77.2	77.4	81.0	81.2	83.0	83.7	81.7	81.1	10.47	0.42	1.45
	77.3		81.1		83.4		81.4				
606	76.3	76.4	77.3	77.6	80.1	79.6	78.0	77.8	10.07	0.46	1.49
	76.4		77.5		79.9		77.9				
607	78.6	78.7	83.5	84.4	81.8	81.1	76.7	76.7	11.03	0.38	1.55
	78.7		84.0		81.5		76.7				
608	83.4	83.7	83.6	82.6	83.4	84.0	81.4	81.7	11.20	0.38	1.70
	83.6		83.1		83.7		81.6				
609	84.8	85.2	84.2	84.4	83.1	85.3	85.0	84.1	10.83	0.37	1.37
	85.0		84.3		84.2		84.6				
610	81.0	81.5	83.6	82.5	84.5	82.8	81.5	80.3	10.21	0.45	1.65
	81.3		83.1		83.7		80.9				
Grand Average	81.2		83.6		83.0		81.2				

It is very difficult to predict baking results from chemical analyses. Flours No. 602 and No. 609 gave high scores by Method 1, Formula 1, but were near the average by Method 1, Formula 2; while flour No. 606 gave a low score by Method 1, Formula 1, but improved its score by Method 1, Formula 2. Formula 1 is more suitable than Formula 2 for bringing out differences in the flours.

The conclusion to be drawn from this work is that the single stage method of adding ingredients is a practical method. It is a much simpler method and therefore is preferable for a standard method of mixing, in testing various flours.

Acknowlegment

The writer hereby acknowledges his indebtedness to all who collaborated in the work of this sub-committee.

The Relation Between the Percentage of Flour and the Percentage of Sugar in a Cake Testing Formula

C. B. Kress

The object of a cake test on flour is to determine the value of a flour for cake making purposes. In general, the relation between flour and sugar in the testing formula is governed by two considerations. First, the generally accepted practice that a good cake should taste sweet. Second, the general quality of the cakes in which the flour will be used.

Regarding the first, the old time cake was one that looked nice, but the modern idea of cake-making is that a cake must not only look nice but it must taste rich and sweet as well. The second general consideration refers to the condition that bakers now make a fancy, high quality cake and a general average quality cake. The high quality cake requires a flour that will carry plenty of sugar and shortening while the average quality cake has plenty of volume, looks nice, but does not carry so much sugar and shortening. Our cake testing formula must be a mean between these two conditions or we must have two formulas.

To demonstrate the effect of the relation between flour and sugar tests were started using equal parts of flour and sugar, gradually increasing and decreasing the sugar ratio. Considering the flour as 100% the sugar therefore varied between the limits of 66⅔% and 150%. As our formula uses a total of 300 g. of flour and sugar, the cakes containing "sugar 150—flour 150" had equal parts of sugar and flour. The cakes with "Sugar 180—flour 120" contained a maximum of sugar, and the cakes marked "Sugar 120 —flour 180" contained a maximum of flour.

The basic testing formula used was as follows:

Flour	150 g.	
Sugar	150 g.	
Hydrogenated Shortening	60 g.	
Salt	2 g.	
Sweet Milk	128 cc.	(which varied as % of flour varied.)
Fresh egg white	70 cc.	
Baking Powder	5 g.	

Method of Mixing

The flour and baking powder are sifted together. Cream the shortening, ⅔ of the sugar, the salt, the milk and the flour for 5 min. on the 2nd speed of a Hobart Mixer and for 1 min. on high. Beat the egg whites with ⅓ of the sugar until stiff. Fold in the egg

whites by hand. Scale at 16 oz. in 8 inch round layer cake pan, 2 inches high. Bake at 310°–325° F.

The following table gives all the results in detail:

TABLE I

CAKES MADE WITH VARYING AMOUNTS OF FLOUR AND SUGAR

Cake Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Flour, g.	180	175	170	165	160	155	150	145	140	135	130	125	120
Sugar, g.	120	125	130	135	140	145	150	155	160	165	170	175	180
Shortening, g.	60	60	60	60	60	60	60	60	60	60	60	60	60
Salt, g.	2	2	2	2	2	2	2	2	2	2	2	2	2
Milk, cc.	150	145	140	137	134	131	128	125	122	120	118	116	114
EggWhite, cc.	70	70	70	70	70	70	70	70	70	70	70	70	70
Baking Powder, g.	5	5	5	5	5	5	5	5	5	5	5	5	5
% Sugar to Flour	66⅔	71	76	81	87	93	100	107	114	122	130	140	150
							SCORE						
Color	100	100	100	100	100	100	100	98	95	95	95	92	90
Volume[1]	1 12/16	1 12/16	1 12/16	1 11/16	1 10/16	1 9/16	1 8/16	1 7/16	1 3/16	1 2/16	1 1/16	14/16	12/16
Texture	96	97	98	98	99	100	100	102	95	95	93	90	80
Grain	98	100	100	100	100	100	100	100	92	90	90	70	50
Sweetness	Fair	Fair	Good	Good	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	V.Sw.	V.Sw.
Keeping Quality	Poor	Fair	Good	Good	Good	V.G.	V.G.	V.G.	V.G.		Cakes all fell		
Top	Hump	Hump	Convex	Convex	Good	Good	Good	Good		Cakes all fell			

[1]Volume is the height of each layer cut in half and doubled

Observations

1. Fresh egg white is preferable to dry egg white since the latter has a disagreeable odor and taste, and it tends to make too compact a grain. A light, spongy texture is of prime importance.

2. If the sugar and shortening are creamed first the cake will have a more close, compact grain, hence it is preferable to mix the whole mixture with the exception of the egg whites, which are best folded in by hand last. Creaming the sugar and shortening first makes a whiter cake, but it is more bready, has less volume and tends to pull in at the edges.

Conclusions

1. About equal parts flour and sugar makes an excellent cake. This is also severe enough so that it requires a good cake flour to perform well.

2. A ratio of sugar to flour above 107% is too much to expect a good cake flour to carry.

3. A ratio of sugar to flour below 100% is easier on the flour and might be used on an ordinary pastry flour, but if this ratio is lowered to 66–70% the resulting cake is too compact and bready.

Viscosity and the Test Cake

EDWARD E. SMITH

The previous subcommittee report on this same subject was read to the 1930 Convention in Chicago and was later published in Cereal Chemistry, **7**: 370.

During the last year many more flours have been examined, using the same methods and procedures as were employed last year. The flours ranged from very short patents to stuffed straights; ranged in viscosity from 22° MacMichael to 78°; and were as widely variant in each viscosity group as were those reported last year.

Another year of work has served only to emphasize and to intensify the conclusions given at Chicago—that the viscosity determination, as such, is meaningless in predicting the score of a white loaf cake baked according to the tentative formulae and procedures of our Committee. Such being the case, the writer feels that it would be a waste of space to burden the record with a mass of meaninglessly detailed data.

This conclusion, however, is not to be understood as minimizing the importance of the viscosity determination in contributing its bit of information to our knowledge of any given sample of flour. The writer feels sure that the viscosity determination gives highly valuable information—*but not upon the test cake.*

This sub-committee, as a result of two years' work, concludes:

1) That the study of viscosity in relation to the test cake should be abandoned as a major project.

2) That viscosity is important as an index of the quality of flour when given its properly weighted place as one of many interrelated factors, but that of and by itself it is entirely meaningless as regards the test cake.

Some Observations on Family Flour

J. A. DUNN

Before starting this investigation, we consulted several Home Economics departments giving service to the housewife, to determine what types of baked goods are most commonly made in the home. All seemed agreed that home baked goods may be divided into four types: (1) batter types, such as muffins, scones, pancakes, biscuits, gingerbread, etc., (2) cakes and cookies, (3) pastry, (4) bread and other yeast-raised goods such as Parkerhouse rolls.

We then undertook this investigation, to determine what type of flour would be best suited for the home. In some parts of the country, only one type is readily available. For example, in the northwest, everyone uses hard wheat flour in the home. In the southeast, practically everyone uses a soft winter wheat flour. These cases are exceptions, for both types of flour are available in the large centers of population, and it is for the housewife to choose what type she will use in her home baking.

Practically all bread is today made in the commercial bakery. This is also true, in large measure, of the other yeast-raised goods; particularly in the urban centers. Approximately three-fourths of the cakes are made in the home. If the baker will give the housewife what she wants, this figure may be cut materially within the next few years. This is also true of pies and pastry. There is one type of baked goods, however, which because of its comparatively poor keeping quality, will always be made in the home to a large extent. This is the batter-type. In this class, we place chemically leavened doughs or batters, not very sweet, and less rich than cakes.

Experiments were carried on to determine what type of flour is best suited to the batter types. Three popular family patent flours, milled from hard wheat, were compared with pastry flours and a package cake flour. The usual tests for absorption, moisture, protein and ash were made and the formulas were adjusted to give similar batters or doughs. Biscuits were made using a hydrogenated shortening, fresh eggs, household baking powder and reconstituted skim milk, to secure uniformity from day to day.

After baking, the biscuits were scored for volume, texture, flavor, color of crust and crumb, tenderness and eating quality. The biscuits made from the family patent flours scored the highest in each case. The volume, texture, flavor, and crust color were superior; but they were not quite as tender as those made from the soft flours, although they seemed flakier. The crumb color of the biscuits made from the soft flours was whiter.

This work was followed up by similar experiments with cheese biscuits, scones, graham and bran muffins and gingerbread. The results showed that the family patent flours had a distinct advantage over softer flours in each case.

It was possible to make good pastry from both types of flour. With the extremely soft flours, it was difficult to make the pastry so that it would roll out well. It also seemed too short when baked. Better crusts were made from the family patents, using normal

amounts of shortening, and the absorption or soaking of the lower crust was not so pronounced.

In testing for cake-making qualities, we made lean pound cake, yellow and white layers and loaves, and a sponge type. By properly adjusting the formulas, we made good cakes from all of the flours, but the soft flours made by far the best cakes in each case. The package cake flour had the highest score in each type of cake.

It might be well to mention two ideas which were developed during our cake experiments. In order to do away with variation in the creaming of the several batches, we creamed enough sugar, salt, shortening and eggs for all the batches in the large bowl of the mixer, and then scaled off aliquot portions into the small bowl, mixing in the milk and the sifted dry ingredients with our standard procedure. By this method we eliminated the variable due to creaming. If the dry ingredients are previously sifted, and the milk and flavoring already scaled, it is possible to have all batches finished in a comparatively short time. It did not seem to hurt the creamed mass to stand while the various batches were mixed. We used the same flour in the first and last batch, with equally good results.

By using the above method, we believe that we have eliminated a possible source of error, and we feel that any variation in the finished cake is due entirely to the flour. This may be due to the mixing quality of the flour, for some flours mix into the batter much more easily and much more smoothly than others. It may also be due to the baking quality of the flour, that is its ability to produce a batter which will have the necessary stability in the oven and which will hold the gas, giving good volume and other cake properties.

Another idea was developed during our cake experiments, which may possibly have escaped notice. It proved very helpful to us, so we mention it here. After scaling the test loaves from each batch, there was some batter left over. These remnants were baked into a loaf in the following manner. The pan was divided into several sections with tin separators placed crosswise or perpendicular to the long dimension of the pan. The remnants were carefully placed in each section and then the separators were carefully removed. After baking, the cake was sliced lengthwise. On examining the long slices, we could see differences in cake quality which might otherwise escape our notice. This idea has been tried in two other laboratories and they are also quite enthusiastic about it.

As a result of the experiments, we reached the conclusion that where they are available, a housewife should keep both kinds of flour among her supplies. The breadstuffs, pastry and the batter types will be of higher quality when baked from the family patent, whereas the cakes will score much higher if made from a soft wheat flour.

REPORT OF THE COMMITTEE ON THE STANDARDIZATION OF LABORATORY BAKING

C. H. Bailey, Chairman

(Read at the Convention, May, 1931)

During the eight years that have elapsed since the appointment of a committee on the standardization of laboratory baking, the work of this Committee has developed in several stages. The first stage, under the chairmanship of L. A. Fitz, involved the study of the methods in vogue in the several testing laboratories, and disclosed a large diversity of practices. The second stage, engineered by the committee headed by M. J. Blish, resulted in the formation of a "fixed" procedure of the type proposed by Werner (1925).[1] From this later emerged several "supplementary" procedures. In the third stage the Committee under the chairmanship of C. G. Harrel subjected the fixed procedure to collaborative study, and disclosed substantial variability in the results obtained by the several technicians who applied the procedure to the same flour samples.

Several reasons for certain of these variations were suggested in consequence of this work, and it then became apparent to the Committee that a concentrated and sustained effort would be necessary to measure the significance of these factors, and to disclose methods for reducing their effect on variability. To this end a plan was developed for raising funds necessary for the maintenance of a research fellowship which would provide for such a study. The success which attended this effort made it possible to appoint a research fellow during the summer of 1930, who assumed this position on September 1, 1930.

With this radical change in procedure which resulted from the adoption of a fellowship plan of study of experimental or laboratory baking, the activities of the Committee underwent an equally

[1] Werner, E. E. The baking test. Cereal Chem. 2:310-314 (1925).

profound change. It then confined itself to advisory relationships, in formulating a general program of work. As was reported at the 1930 Convention, the Committee recommended that the fellowship be located at the University of Nebraska, where adequate mechanical facilities and personnel insured satisfactory conditions for work. This recommendation was approved by the Association in convention.

Several meetings of the Committee were held during the week of the 1930 Convention, and it was then agreed that an attempt should be made to study the mechanization of the standard baking procedure. Previous observations had led to the suggestion that the application of mechanical devices to mixing and moulding the dough might serve to reduce the large variability encountered with hand operations by different technicians. Relations of different types of ovens to the characteristics of the resulting bread were also to be included in the early studies. Considerable progress has been made by the Fellow in these studies during the first eight months of work, as will be evident from the report which follows.

It is inevitable in the instance of the cooperative relations such as we have set up with the University of Nebraska that the head of the laboratory in which the work is conducted must assume the major responsibility for the day to day work of the Fellow and the organization of reports. The committee itself can merely develop and approve general plans and policies. Under the direction of Dr. M. J. Blish, qualified and competent leadership has been provided. The Committee and the Association owe to Dr. Blish, and to the University of Nebraska, a large debt of gratitude for the thought and effort, and the laboratory facilities contributed to this enterprise.

Finances available for the support of this work should be sufficient to maintain it at the present level of expense through the remainder of 1931. This makes it possible for the newly appointed committee to continue active work for nearly as extended a period of time as did the retiring committee after making allowance for the time that was involved in fitting up the laboratory and installing and tuning up the new equipment acquired for this work.

REPORT OF ACTIVITIES OF THE A. A. C. C. RESEARCH FELLOW

P. P. Merritt[1] and M. J. Blish

Department of Agricultural Chemistry, University of Nebraska, Lincoln, Nebraska

(Read at the Convention, May, 1931)

Following the adoption by the A. A. C. C. of the Werner (1925) type of laboratory test baking procedure as a basis for the tentative standard method, in March, 1928, Harrel (1929) conducted an extensive series of collaborative tests using specifications as they appear in the report of the 1928 Committee (1928). The results showed an astonishingly wide range of variation in test loaf characteristics among the different collaborators. They demonstrated clearly that there could have been no uniformity of conditions under which the collaborators conducted their tests. There were obviously wide variations either in oven temperatures or fermentation temperatures or both. The personal element in mixing, kneading and moulding the dough must also have been a heavily contributing factor.

The results of Harrel's (1929) collaborative tests emphasized the necessity of a systematic study of those factors that are believed to be chiefly responsible for the great variability among different operators. The eventual development of means to control all factors with the possible exceptions of yeast variability and atmospheric pressure would seem to be within the range of reasonable expectation and possibility. This situation led Harrel (1929) to propose and, with the Association's approval, successfully to promote the establishment of the present A. A. C. C. Fellowship, designed for the specific purpose of studying the more important factors of variability in test baking. The work of the Fellow has therefore been planned, insofar as available mechanical facilities and the intelligence of the Committee would permit, toward the establishment of facts which, it is to be hoped, will lead to a better understanding of the manner in which these factors of variability operate. It is expected that results of this and similar work will serve a useful and practical purpose in laying some foundation for substantial improvements in some of the specifications of the basic procedure.

The process of revising and improving these specifications is no simple matter, for there are several considerations to be weighed and balanced against each other. There is the desirability

[1] Research Fellow, September 1, 1930 - September 1, 1931.

of eliminating the personal element in the operations of mixing, punching, and moulding. Does mechanical moulding offer advantages over hand moulding sufficient to justify the initial cost of such mechanical moulders as are now available? When comparing methods of procedure in their numerous modifications the question always arises as to which method may be expected to give the most informative results. To what extent should convenience to the operator enter into the picture? What specific procedure will give the most consistent and invariable results when used by a single operator, and which will give the maximum concordance of results among workers in different laboratories? These and sometimes other issues inevitably enter into the fixing of specifications for any step of the baking procedure.

The work of the Fellow has thus far centered largely around studies of various methods of mixing, moulding, and of oven types and oven performance under varying conditions. Several manufacturers have kindly lent articles of equipment for the temporary use of the Fellow. Grateful acknowledgment is hereby extended to the Freas Thermo-Electric Co., the Despatch Oven Co., the Thomson Machine Co., and the Hobart Mfg. Co., not only for the loan of the articles of equipment but also for their constant readiness to be of all possible service in the development of a baking test that will be best adapted to the needs of the cereal chemist.

The preliminary report (1930) indicated the analyses of the flours that have been used throughout the work thus far. Therein was also described the manner of storing the flour, methods of handling the yeast, pans, etc. The report was concerned chiefly with studies on mixing, moulding, absorption and greasing vs. non-greasing of pans, wth the greater emphasis on the mixing and moulding experiments. Since the present report will discuss additional mixing and moulding experiments, some of the data of the preliminary report will again be brought forward in this discussion, in order to provide a convenient basis for considering the different modifications of procedure in relation to each other.

Mixing Experiments

Tests with the First Model of the Hobart-Swanson Mixer

The mixing studies discussed in the preliminary report were supplemented by later studies occasioned by the arrival, in January, of a standard Hobart mixer, together with a newly designed mixing attachment embodying the principle originated by Swanson and Working (1926), and constructed especially for handling

doughs from 100 g. of flour. Thanks are due to the Hobart Manufacturing Co., for the loan of these mixers. The Swanson type of mixer was reported by Heald (1930) to give a very rapid, efficient and thorough mixing, as compared with the ordinary Hobart mixer using the small bowl and paddle arm. The new attachment as received from the Hobart Co., appeared to be a neat, compact and well-constructed mixer. In operation, however, it showed one objectionable feature, namely, a pronounced tendency for a considerable portion of the dough, after some seconds of mixing (varying somewhat with different flours) to climb the upper pins and "ride" without further mixing. After a series of experiments with the Hobart-Swanson attachment, it was turned over to Dr. Swanson, who altered certain mechanical features of the pins and bowl in such a manner that the trouble was entirely eliminated providing 200 g. of flour were used. Dr. Swanson contemplates further alterations that will permit satisfactory operation with *either* 100 or 200 g. of flour.

In Table I following, appear the results of studies with the Hobart-Swanson mixer, using different mixing periods and different flours.

TABLE I

EXPERIMENTS WITH HOBART-SWANSON MIXER AS ORIGINALLY RECEIVED

Mixing Time	Number of Replicates	Mean Volume	Standard Deviation	Coefficient of Variation
min.		cc.		
		Flour No. 1		
1	20	473	7.01	1.48
1½	20	476	8.28	1.74
3	10	496	7.97	1.61
3½	10	491	12.16	2.48
		Flour No. 2		
1	20	514	15.07	2.93
2	20	521	11.72	2.25
3	10	536	13.88	2.59
3½	10	547	9.93	1.81
		Flour No. 3		
1	20	566	12.61	2.22
1½	20	587	12.94	2.20
2	20	600	24.19	4.03
2½	20	617	22.89	3.71
3	10	645	15.01	2.33
3½	10	666	16.68	2.50

It is of interest to compare the results in Table I with those obtained by Heald (1930). The Hobart-Swanson mixer had but one speed, 112 r.p.m., and closely approximates the second speed in Heald's work, which was 109 r.p.m. When operating at that

speed, Heald's loaf volumes declined rapidly after 1 min. of mixing time, whereas in these studies, all three flours easily withstood 3½ min., with volumes steadily increasing with the length of the mixing period. This may be due to the previously-noted tendency of the dough to climb the pins and ride without as thorough a mixing as Heald's doughs received.

Performance of the Modified Hobart-Swanson Mixer

After Dr. Swanson had made the alterations whereby doughs from 200 g. of flour could be thoroughly and uniformly mixed with the complete elimination of the objectionable feature that has been indicated, he shipped the mixer back to the Research Fellow, who made a few experiments to test its action in the modified form. The results were as shown in the Table IA.

TABLE IA

Experiments with the Modified Hobart-Swanson Mixer Using Flour No. 3

Mixing Time	Variates	Mean Volume	Standard Deviation	Coefficient of Variation
min.		cc.		
1½	10	650	12.25	1.88
2	20	681	20.45	3.00
2½	10	694	21.71	3.13

These figures are admittedly few in number, and are merely suggestive. It is considered advisable to postpone further studies until the Hobart-Swanson mixer is put in its final form. The figures indicate, however, that the modification, which eliminated the tendency of the dough to "ride" on the pins, provides for more thorough mixing than was secured from the mixer as originally received. Loaf volumes of 681 and 694 cc. for 2 and 2½ min. mixing, respectively, are considerably greater than the corresponding values of 600 and 617 cc. secured with the original mixer (see Table I). This second series of experiments, using the modified Hobart-Swanson mixer, should provide a better basis for comparison with Heald's (1930) results than did the former series, for both machines apparently gave thorough mixing, at very nearly the same speed. It may be observed, however, that even with the more thorough mixing the flour had not reached its maximum volume development in 2 min. time, whereas Heald's data show a rapid decline in volume after 1 min.

Tests with Regular Hobart Mixer

Mixing studies were also made using the ordinary Hobart Mixer, with the 3 qt. bowl and paddle arm, information having

been received from various sources that this equipment is suitable and convenient for mixing doughs from 100 g. of flour. No studies using the Hobart mixer in conjunction with various dough hooks have as yet been undertaken by the Fellow. In this connection it should be noted that the mixing procedure that has been extensively used by the Associate Committee on Grain Research in Canada (Geddes, 1929) involves the small Hobart mixer equipped with two hooks and operated for 3 min. at second speed. The data secured from studies with the Hobart mixer using the paddle arm and doughs from 100 g. portions of flour are shown in Table II, following:

TABLE II

Experiments with Hobart Mixer Using Three Quart Bowl and Paddle Arm

Mixing Time on 2d Speed	Mixing Time on High Speed	Number of Replicates	Mean Volume	Standard Deviation	Coefficient of Variation
min.	min.		cc.		
			Flour No. 3		
½	1	40	620	19.40	3.12
½	1½	39	622	10.88	1.75
½	2	39	620	16.09	2.60
½	3	20	615	10.91	1.77
			Flour No. 2		
½	1	20	527	5.52	1.05
½	1½	20	536	13.43	2.50
½	2	20	548	11.60	2.12
½	3	20	535	13.95	2.61
			Flour No. 1		
½	1	20	484	4.19	0.87
½	2½	20	495	8.93	1.81

From the results shown in Table II it is apparent that the duration of the mixing period is a far less critical factor when using the Hobart machine with the paddle arm than is the case when doughs are mixed according to the Swanson principle. This is presumably due to less mechanical modification with the former than with the latter, when the mixing time is extended.

A few experiments were made using the Hobart mixer with the paddle arm on doughs from 200 g. rather than from 100 g. of flour. These doughs were divided into two equal portions after mixing. They were mixed for ½ min. on second speed and 1½ min. on high speed. For 15 loaves baked from flour 3 and mixed in this manner the average loaf volume was 642 cc. as compared with the average of 622 cc. for the 100 g. doughs, as shown in Table II. There were no essential differences as to variability. The appreciably larger loaf volume, if significant, may be due to a slightly

greater mixing action when the larger amounts of dough are subjected to that particular procedure.

Correlation of Results with Different Baking Procedures

One of the main objectives of the Committee in undertaking the studies on mixing has been an answer to the following question: Is it possible to secure the same degree of mixing from different mixing methods by the establishment of time factors, and thus eliminate the necessity of ultimately specifying one type of mixing for the basic procedure? The answer to this question would appear to be definitely in the negative whenever mechanical mixing has proceeded to a point where modification of the gluten enters into the picture. This may be appreciated from a study of certain data in Table III.

TABLE III

COMPARISON OF DIFFERENT MIXING METHODS

Mixing Method	Amount of Flour	Mixing Time	Mean Volume	Coefficient of Variation	Number of Replicates
	g.	min.	cc.		
		Flour No. 1			
Hand	100		474	2.08	160
Fleischmann	500	¾	490	3.09	90
Fleischmann	500	1½	494	2.12	210
Fleischmann	500	3	525	3.32	60
Hobart-Swanson	100	1	473	1.48	20
Hobart-Swanson	100	3	496	1.61	10
Hobart-Swanson	100	3½	491	2.48	10
Hobart	100	1½	484	0.87	20
Hobart	100	3	495	1.81	20
		Flour No. 3			
Hobart	100	1½	620	3.12	40
Hobart	100	2	622	1.75	39
Hobart	100	3	615	1.77	20
Hobart-Swanson[1]	100	1	566	2.22	20
Hobart-Swanson[1]	100	2	600	4.03	20
Hobart-Swanson[1]	100	3½	666	2.50	10
Hobart-Swanson[2]	200	1½	650	1.88	10
Hobart-Swanson[2]	200	2	681	3.00	20
Hobart-Swanson[2]	200	2½	694	3.13	10
Hand	100		553	1.80	60
		Flour No. 2			
Hand	100		497	1.80	20
Hobart-Swanson	100		514	2.93	20

[1] As originally received from Hobart Co.
[2] After modification by Dr. Swanson.

Inspection of the data in the foregoing table reveals that the comparative action of different mixing procedures varies with different flours. Thus when flour No. 1 is mixed in the Hobart mixer, an increase of 1½ to 3 min. gives a corresponding increase in loaf

volume of 484 to 495 cc. When the same flour is mixed in the Hobart-Swanson mixer for 1 and 3 min. respectively, the corresponding volumes are 473 and 496 cc. This would indicate that the action of both mixers was the same. An entirely different picture is presented by the corresponding data in the case of flour No. 3. Here the Hobart mixed loaves showed no significant volume differences over a time range of from 1½ to 3 min., the volumes for 1½, 2, and 3 minutes respectively, being 620, 622, and 615 cc. When mixed in the Hobart-Swanson mixer however, the volumes for 1, 2, and 3½ min. respectively, are 566, 600, and 666 cc.

With all three flours, No. 1, No. 2, and No. 3, hand mixing appears to give results closely approximating those obtained by mixing for 1 min. on the original Hobart-Swanson mixer. These were the lowest volumes obtained, although fairly satisfactory as to variability.

Hand mixing is, of course, less convenient than machine mixing. It produces smaller loaf volumes than can be obtained by machine mixing. However, operations that tend toward the production of large volumes usually show a trend toward greater variability. This is in harmony with recent findings of Geddes, Goulden, Hadley and Bergsteinsson (1931).

The close agreement between values for hand-mixing and for mixing 1 min. with the Hobart-Swanson machine for the 3 flours indicates that it may be possible to duplicate — or in any event closely approximate — the results obtained by hand mixing with almost any of the more familiar types of mechanical mixers. This would make it possible for the operator to take his choice and still adhere to the specifications of the basic procedure. He would merely have to determine by experiment the mixing time to use for his particular machine in order to duplicate the results obtained by hand mixing.

Mechanical Modification in Dough Mixing

Since hand and machine mixing give concordant results only when the machine mixing time is reduced to one minute or less, it is apparent that the lack of agreement when the longer machine mixing times are employed is due to that type of mechanical modification that is generally referred to as "gluten development." Since provision for studying this factor is made in Supplementary Method D, it would seem desirable to eliminate it as far as possible in the basic procedure itself, and confine mixing more exclusively to the mere incorporation and thorough distribution of

the ingredients, excepting in instances where Method D is intentionally used. Since the present specified hand-mixing procedure certainly involves a minimum of gluten development, it should be retained, with the understanding that any machine mixing that gives comparable results can be used as an alternative. Each operator, however, must determine by experiment how to operate his particular machine, in order to duplicate the hand method.

For the machine mixing of the small doughs the Hobart and the Swanson mixers are believed preferable to the Fleischmann which requires several hundred grams to operate satisfactorily. The Swanson type when put in its finally perfected form will doubtless be superior for those who may desire to have a "dual purpose" machine that will furnish mixing alone, or mixing plus mechanical modification, and do either or both jobs in the minimum time.

It remains, however, to be established beyond reasonable doubt that the concordance between hand mixing and short time machine mixing will hold for all flours, and a further study should involve a large number of flours whose characteristics vary over a wide range.

Moulding Experiments

General Consideration of Hand vs. Machine Moulding

The personal element in moulding dough by hand is generally regarded as an important cause of variability among replicate tests by an individual operator and of discordant results when different technicians bake the same flour. Moen (1929) reported experiments in which he found the latter to be true both with experienced and inexperienced operators. Fifield and Weaver (1930) found a variability of 4.35% in hand moulding, and only 1.2% to 1.9% when doughs were moulded in a specially modified Thomson One-man moulder.

Very recently, Geddes, Goulden, Hadley and Bergsteinsson, (1931) have prepared a report of an extensive study of variability as influenced by mechanical moulding, involving more than 4,000 individual bakes, including statistical analyses of their data. They conclude that "machine moulding may reduce but not eliminate the large differences in mean loaf volume which different operators secure in baking the same flour." They used a Model G Thomson Roll Moulder, as specially adopted by the Thomson Machine Co., for small laboratory loaves, and doubtless similar to the one that has been used throughout the experiments here reported. Grate-

ful acknowledgment is hereby extended to the Thomson Machine Co. for the loan of the Model "G" Moulder.

Adjustment of Machine Moulder

There are only two adjustments that can be made on the moulder. The distance between the two smooth rolls through which the dough first passes is adjustable, and there is a gauge showing a definite numerical value for each setting. The other adjustable feature is the distance between the compression plate and the drum. This has no gauge, and the different settings are here recorded in terms of the distance from the discharge end of the plate as taken vertically (not radially) to the drum. The flat compression plate or "shoe," 3½ in. wide was used exclusively.

The first series of experiments involved different adjustments of the machine in order to find what adjustments gave optimum results in terms of volume and internal characteristics. Table IV, following, shows results at different adjustments of the shoe with the rolls remaining at "2" throughout the series. Samples of each of the three flours were moulded at each of the shoe settings. Each value recorded in the table is the average for all three flours, the flours being, of course, equally represented as to the number of samples. Table V deals with different roll settings while the adjustment of the compression plate is held constant. Flour No. 3, only, was used in securing the data presented in Table V.

TABLE IV

Results with Different Settings of the Compression Plate in Machine Moulder

Distance	Number of Replicates	Mean Loaf Volume	Coefficient of Variation	Roll Setting
inches		cc.		
1 9/16	60	474	1.44	2
1 10/16	60	535	2.53[2]	2
1 11/16	30[1]	547[1]	2.38[1]	2
1 12/16	60	565	2.55	2

TABLE V

Effect of Varying Roll Setting

Roll Setting	Number of Replicates	Mean Loaf Volume	Coefficient of Variation	Compression Plate	Remarks
		cc.			
1	20	643	3.18	1¾	Dough badly torn
1¼	10	627	2.92	1¾	Dough badly torn
1½	30	647	2.95	1¾	
2	20	651	2.54	1¾	

[1] These values should replace the first set of values in the second table on p. 67 of *Cereal Chemistry*, Vol. 8, (Preliminary Report of Research Fellow), which are in error.
[2] This should replace the figure 1.44 in the second set of values in the same table of the Preliminary Report, which is a typographical error.

The data in the Tables IV and V indicate that the adjustment of the compression plate is a more important and critical feature than is the setting of the sheeting rolls. When the rolls were set closer than "2" there was a tendency toward tearing of the dough, especially at settings of "1" and "1¼." This, however, does not appear to have very profoundly affected either the loaf volume or the variability. A variation of from 1-9/16 to 1-12/16 in. in the setting of the compression plate, however, made a difference of 91 cc. in mean loaf volume, with the largest volume at the 1-12/16 in. setting. The optimum adjustment of the machine appears to be realized with the rolls set at "2" and the compression plate at 1-12/16 in., under these conditions.

These results agree in general with data secured in a preliminary study with the same moulder by Markley (1930). They are not in agreement with one of the findings of Geddes, et al (1931) who report that "variations in the setting of the sheeting rolls were found to have a more pronounced effect on volume and texture than variations in the adjustment of the compression or former plate." This disagreement in results is difficult to understand, unless they used a different compression plate than the one designated herein. They find the optimum roll adjustment to be at "2," with the best compression plate setting at 1-10/16 in.

Operations tending to produce the larger volumes tend also toward greater variability. The larger volumes in machine moulded loaves tend to show characteristics similar to those of hand moulded loaves, but the smaller volumed machine moulded loaves showed a trend toward finer grain, thicker cell walls, and harsher texture. These two experiences check with those reported by Geddes et al (1931).

Comparative Tests of Hand and Machine Moulding

The next series of experiments involved comparisons of hand with machine moulding. In the first series all three flours were used, and the doughs were mixed by hand. Each flour was baked for two consecutive days, 20 loaves a day, and on each day 10 of the loaves were moulded by hand, while the other 10 were machine moulded. The results from this series are shown in Table VI.

The values presented in Table VI show volume differentials favoring the hand-moulded doughs in all three flours, although the differences are not important with flours 1 and 2. In two out of the three flours the variability was lower with the machine-moulded doughs. These observations are in general agreement with those of Geddes et al (1931).

A second series of similar experiments was undertaken, but in this series the doughs were mixed by machine instead of by hand. The only machine mixer available at that time was a Fleischmann mixer. This called for mixing doughs from 500 g. of flour, and scaling them into 5 equal portions, each subsequent operation being carried out with 5 loaves, instead of one, at the time. The mixing time was 2 min. The data pertaining to this series are shown in Table VII.

TABLE VI

Hand vs. Machine Molding on Hand Mixed Doughs from 3 Flours

Flour	Number of Replicates	Method of Moulding	Mean Volume	Standard Deviation	Coefficient of Variation
			cc.		
1	20	Hand	462	9.3	1.95
1	20	Machine	445	6.43	1.45
2	20	Hand	489	9.65	1.95
2	20	Machine	483	11.45	2.35
3	20	Hand	603	13.2	2.17
3	20	Machine	550	8.4	1.48

TABLE VII

Hand vs. Machine Moulding on Machine Mixed Doughs

Flour	Number of Replicates	Method of Moulding	Mean Volume	Standard Deviation	Coefficient of Variation
			cc.		
1	10	Hand	473	9.02	1.09
1	10	Machine	485	13.4	2.76
2	10	Hand	497	11.03	2.2
2	10	Machine	524	11.8	2.25
3	30	Hand	651	27.8	4.29
3	30	Machine	623	18.3	2.9

The values presented in Table VII show consistently higher volumes than in the case of the hand-mixed doughs, as would be expected. For flours 1 and 2, machine moulding gave larger loaf volumes than hand moulding, which is in contrast to the results with hand-mixed doughs. With flour 3, however, the higher volume remains in favor of the hand-moulded doughs.

It may also be noted that the variability tends to run slightly higher in the second than in the first series. These findings appear to lend support to one of the main conclusions reached in connection with the mixing studies. This is that when doughs are machine mixed to the point where mechanical modification of the gluten becomes a factor, greater inconsistencies and greater variability are encountered than where the mixing has been confined

more exclusively to the mere incorporation and distribution of the dough ingredients. It emphasizes the desirability of avoiding mechanical "gluten development" in the basic procedure, although in no way minimizing the potentialities of Supplementary Method D, which provides for the study of mechanical modification exclusively.

It is extremely difficult to evaluate properly the results of these moulding studies as to their true meaning. Although the volume of work thus far accomplished by the Research Fellow on this phase of the project is small as compared to the extensive series of tests recently conducted by Geddes et al (1931) the conclusions are of essentially the same character, that is to say, the introduction of mechanical moulding may be expected to contribute something toward the elimination of variability. It is convenient and time-saving. In replicate baking tests, using the same flours day after day and week after week, one is frequently confronted by unmistakable evidence that other factors, including mixing, punching, yeast variability and possibly unknown oven peculiarities, contribute as much to variability as does moulding, if not more. Certain evidences of this will be discussed more fully later in the report.

Oven Studies

Three Types of Oven Used

A very considerable portion of the Research Fellow's time and effort has been devoted to studies of certain types of ovens, in the hope of obtaining information that may be of assistance in the matter of eventually deciding upon oven specifications that will best meet the requirements, conditions and purposes of the standard baking test. Special acknowledgment and thanks are due to the Freas Thermo-Electric Co., and to the Despatch Oven Co., both of which have shown every willingness and desire to build ovens suited for the experimental baking requirements of the cereal chemist. Each company placed an oven at the disposal of the Research Fellow. Any idea of competition between manufacturers has been scrupulously avoided in conducting these oven tests, which are to be regarded solely as tests of oven *types*.

Oven X has a capacity of eight loaves, and is equipped with a rotating shelf and a fan for producing a forced draft. The heating elements extend horizontally along the side nearest the fan.

Oven Y is of similar capacity, and is provided with the rotating shelf, but no forced draft. It has both top and bottom heating elements.

Oven Z is a small oven of the size and construction of the ordinary laboratory drying oven, with capacity of two loaves, and a home-made rotary shelf. Heating elements are only in the bottom, and the door covers the entire front of the oven. Each of the three ovens has a thermoregulator.

In Oven X, the thermometer extended down parallel with the shaft supporting the rotary shelf, and about 2 in. directly in front of the shaft. In Oven Y, the thermometer extended down vertically about midway between the shaft and the left inner side wall of the oven. In Oven Z, the thermometer was located as close as possible to the center of the revolving shelf. In all cases it was possible to arrange the pans so that the inner top edge of each pan passed the thermometer bulb at a distance of 5 cm., which is according to present specifications. For the purpose of taking temperature readings with thermocouples, a thermocouple was installed as closely as possible (without touching) to the thermometer bulb in each oven. Calibrated copper-constantan thermocouples were used, with the cold junction at 0°C., and readings were made with the Type K Leeds and Northrup potentiometer. These conditions apply for all temperature measurements here recorded.

Harrel and Lanning (1929) reported some experiments with three types of ovens including types X and Y as here described. They stated that "excellent baking results were obtained with all 3 ovens." They showed the importance of accurately specifying the location of the thermometer bulb with reference to the pan, and they determined the effect of different loads on the oven temperatures.

In these oven studies the first undertaking was to determine degree and regularity of temperature fluctuations in Ovens X and Y when empty. Both thermocouple and thermometer readings were made at one-minute intervals for 30 min., with results as shown in Fig. 1.

Oven Temperatures

The time-temperature curves in Fig. 1 merely show that the temperature fluctuations in both ovens occur with consistent regularity, the high and low spots registering the limits as well as the frequency at which the heat turns on and off. The temperature degree range is around 6° for each oven, with Oven Y showing greater frequency of make and break in the current. The curves also show the manner in which the thermometer readings lag behind and below the thermocouple values.

Incidentally Fig. 1 also shows the temperatures that the *empty* ovens should register, both by thermocouple and by thermometer, in order that the temperature drop will bring the oven temperatures within the prescribed range, i.e. 230±5°C., when they are loaded with five loaves, respectively.

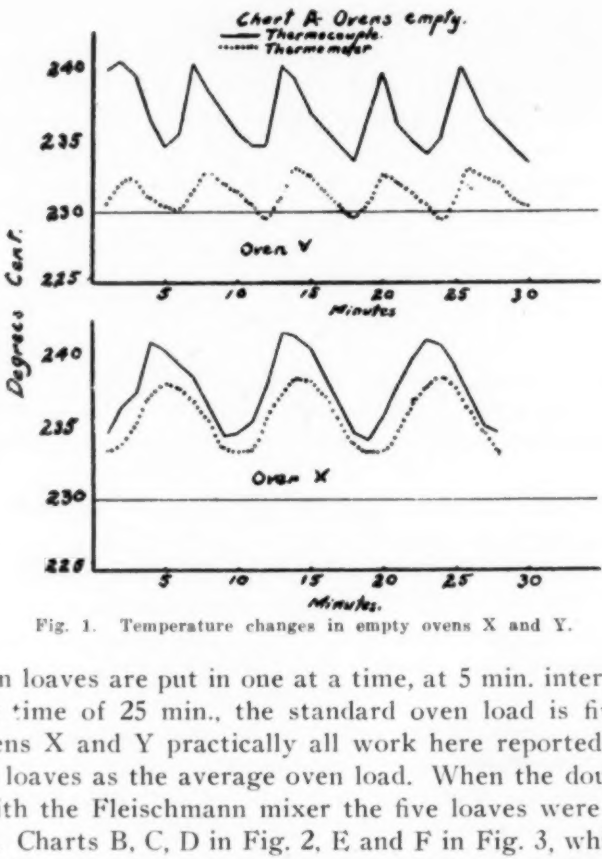

Fig. 1. Temperature changes in empty ovens X and Y.

When loaves are put in one at a time, at 5 min. intervals, with a baking time of 25 min., the standard oven load is five loaves. With ovens X and Y practically all work here reported has been with five loaves as the average oven load. When the doughs were mixed with the Fleischmann mixer the five loaves were put in at one time. Charts B, C, D in Fig. 2, E and F in Fig. 3, which follow respectively show time-temperature relations for Ovens X and Y when loaded with five loaves at a time, and with one loaf at a time, also for oven Z with its two loaf charge.

The curves are self-explanatory, and show that in all cases the The curves show different characteristics depending upon whether *average oven temperature* falls easily within the range of 230±5°C. the loaves were introduced singly, or whether the whole charge was put in at once, the reasons for these differences being so obvious as to require no discussion. The essential feature of practical importance is that the range and maintenance of temperatures

are in all instances sufficiently satisfactory to meet any reasonable requirements that are likely to be encountered in experimental baking.

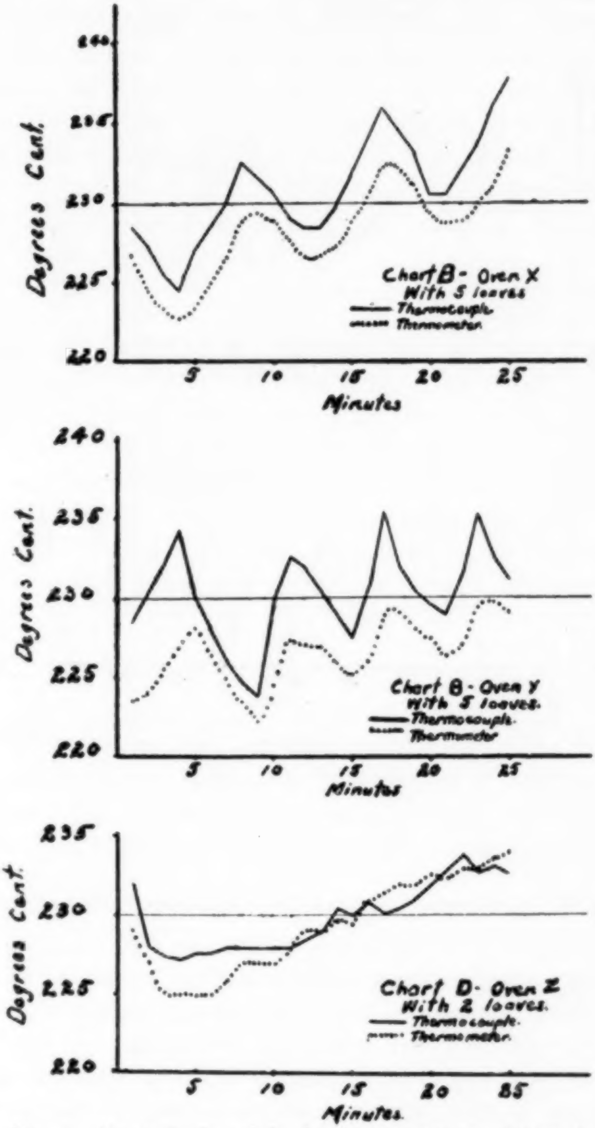

Fig. 2. Charts B, C, and D showing temperature changes in loaded oven when loaves were all introduced at the same time.

The drop in temperature that occurs when the empty oven is loaded with five loaves corresponds closely to values reported by Harrel and Lanning (1929), who determined the drop in tempera-

ture for loadings ranging from two to eight loaves. No further information on this point should be necessary. The data available should permit one to adjust one's thermoregulator to meet the present temperature specifications for any reasonable load. A

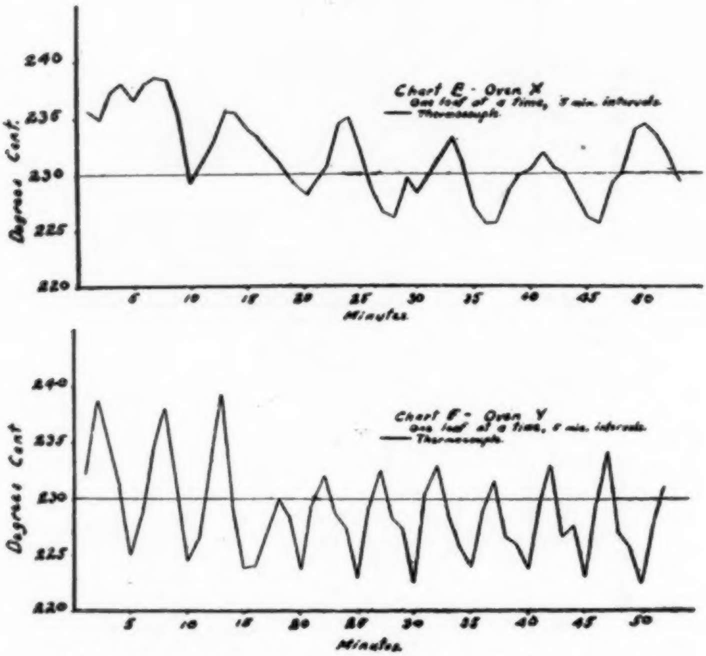

Fig. 3. Charts E and F showing temperature changes in ovens X and Y when loaves were introduced at 5 minute intervals.

glance at Charts E and F will show that opening the oven door to withdraw one loaf and insert another caused a temperature drop so small as to be negligible for all practical purposes.

Special Conditions Causing Inconsistent Baking Results

Assuming that all three types of ovens will satisfactorily meet the specifications as to degree of temperature, and its maintenance, there arise the important issues as to the manner in which the bread characteristics and variability, respectively, are related to the types of ovens under consideration. In the process of studying these matters under existing conditions several minor difficulties arose, and some attempts were made to arrive at an understanding of their cause.

As a background for a discussion of what was perhaps the most serious problem encountered, it is necessary to make a brief reference to the mixing and moulding studies that have already

been reported. In those experiments, for the purpose of insuring oven conditions as uniform as possible throughout an entire day's baking, a pan of water was always present in the oven, and a set of five "dummy" loaves was baked just before the first batch of regular loaves, the dummies being intended to furnish the same set of conditions for the first regular batch as existed for the succeeding batches. When loaves were introduced one at a time, the five dummies were inserted in the same manner, and a similiar procedure was employed at the end of the bake. This insured that the first and last individual loaves were subjected to the same oven conditions as the intermediate loaves.

Later events justified this precaution, for when the oven studies themselves were initiated, it was thought advisable to note the effect, if any, of omitting either the water or the dummies, or both, and it was then that the trouble was first encountered. The first instance occurred when baking 20 loaves of flour 3, ten in Oven X and ten in Oven Y, on the same day. The Fleischmann mixer, mixing dough for five loaves at a time, was used. A pan of water was used in each oven but no "dummies" preceded the first batch of five loaves in either oven as had been the customary procedure. The first five loaves baked in oven Y averaged 550 cc. in volume, while the second set of five average 660 cc., a difference of 110 cc. The individuals in each set of five checked each other very closely, their coefficient of variability being only 0.95. The same was true of the second set, which had a C. V. of 1.80. The C. V. of the ten loaves taken together, however, was 9.20. This situation did not occur, in the instance of Oven X where the average volume for the 10 loaves was 646 cc. with a C. V. of 3.25.

A series of 20 loaves from flour 3 was then baked, five at a time, but without either water or dummies, in Oven Y. Here the same experience was had, that is, the first 5 loaves were decidedly out of line with the remaining 15, averaging 474 cc. in volume as against the average of 634 cc. for the other 15. Two similar series of 20 loaves each, with flour 1, did not show this peculiarity. A number of sets of experiments were then undertaken in an effort to establish precisely the cause of this peculiarity. The results showed certain definite trends, although occasional inconsistencies occurred.

To present even a summary of all the data secured from these studies would render this report unnecessarily voluminous without serving any useful purpose. The remaining discussion of the particular phase of the oven studies will therefore be confined to a

brief statement of certain conclusions for which there is reasonable justification and which are as follows:

1. In the case of Ovens X and Y, when baking in batches of five loaves at a time, there is frequently a decided tendency for the first lot of five to be conspicuously out of line with the remaining lots. They frequently showed loaf volumes of more than 100 cc. below normal.

2 This tendency was observed only with flour 3, a high protein flour that would be regarded as of excellent breadmaking quality by any standards.

3. It showed a far greater tendency to occur in the natural draft oven than in the forced draft type.

4. It never occured in either oven when water was used in conjunction with a preliminary run of "dummy" loaves. When either of these items was omitted, it was likely to occur, and did so repeatedly in Oven Y, but not invariably. It happened only once in Oven X, and that was when both water and dummies were omitted. In other instances it did not occur in Oven X under any circumstances.

5. When loaves were mixed singly or in pairs, and inserted in the oven in the same way, with a maximum load of five or six in the oven at once, the phenomenon did not occur in any instances in either oven.

These findings appear to justify a general statement to the effect that when baking in any type of oven in accordance with a system that involves putting in several loaves at a time, it seems advisable to have a pan of water in the oven and to bake a set of dummy loaves just before the first batch of regular loaves. If this is not done, the first lot of loaves are likely to give untrustworthy results. These precautions appear unnecessary when loaves are mixed and baked one or two at a time.

Use of Water in the Oven

The foregoing discussion of course raises a question as to whether or not the keeping of a pan of water in the oven will seriously influence loaf characteristics. A brief study of this is summarized in Table VIII.

These tests furnished no basis for presumption that the introduction of an open pan of water in either type of oven will significantly affect loaf characteristics. There were no appreciable differences in volume, grain, texture or color that could be attributed to the water.

TABLE VIII

EFFECT OF PAN OF WATER IN OVEN UPON LOAF CHARACTERISTICS

Flour	Oven	Water	Loaf Volume	Standard Deviation	Coefficient of Variation	Number of Replicates
			cc.			
3	X	No	598	17.89	2.99	10
3	X	Yes	609	18.92	3.11	10
3	Y	No	604	16.74	2.77	10
3	Y	Yes	606	12.07	1.99	10

Effect of 10° Differential Influenced by Oven Types

How important is the strict maintenance of oven temperature as prescribed in the present method specifications? Two days' experiments were given over to a brief consideration of this question. On one day 20 loaves of flour 3 were baked in Oven X, 10 at 230±5°C., and 10 at 220±5°C., or 10° lower. The next day the experiment was repeated, using Oven Y. The results are summarized in Table IX.

TABLE IX

EFFECT OF A 10° C. DIFFERENTIAL IN BAKING EXPERIMENTAL LOAVES

Flour	Oven	Temp.	Loaf Volume	Standard Deviation	Coefficient of Variation	Number of Replicates
		degree C.	cc.			
3	X	230±	595	16.37	2.75	10
3	X	220±	594	13.82	2.33	10
3	Y	230±	614	16.21	2.64	10
3	Y	220±	613	24.53	4.00	10

In these brief studies, involving Ovens X and Y, there was no evidence of the slightest difference in loaf characteristics as produced by the 10° drop in oven temperature, aside from crust colors, which showed perceptibly darker for the higher temperatures.

It has been suggested by Dr. E. E. Werner, the originator of the present A. A. C. C. standard baking test, and by others as well, that the test is likely to be more informative if the baking is done without the use of the top heat in the oven, thereby affording a greater differentiation as to top crust characteristics among different flours. In order to test this idea with flour 3, using the same oven at the same temperatures, both with and without the top heat, 20 loaves were baked the same day in Oven Y, 10 of which were with both top and bottom heat as usual and 10 with the top heat turned off. To meet the required temperature in the latter case necessitated a re-setting of the thermoregulator. With both top and bottom heat, average loaf volume was 611 cc., with

C. V. of 3.22. With bottom heat only, average volume was 607, with C. V. of 1.84. Here, as in the instance of the 10° temperature differential, the only noticeable effect on loaf characteristics was in regard to crust color, which was perceptibly lighter without top heat. Variability was less without top heat, but the number of variates is too few for this to be of any serious significance. Whether or not the elimination of top heat will, in the long run, provide better differentiation among various flours, as well as less variability, will require special and more extensive investigations.

The final stage of the work to be considered in this report involves experiments intended to indicate the manner in which loaf characteristics and variability are influenced respectively by the three types of ovens already described. Due to the inconsistencies that were encountered when mixing and baking five loaves at a time, the data brought to bear on this phase of the work is here confined to loaves mixed either from 100 or 200 g. portions of flour in the Hobart mixer. No dummy loaves were used in any of these bakes, and in but one or two instances was water used.

For the purposes of convenience and brevity all data for each flour and for each oven are averaged, the averages appearing in Table X.

TABLE X

LOAF CHARACTERISTICS AND VARIABILITY AS RELATED TO TYPES OF OVENS

Flour	Oven	Number of Replicates	Mean Loaf Volume	Standard Deviation	Coefficient of Variation
			cc.		
3	X	100	610	16.75	2.74
3	Y	100	619	14.2	2.30
3	Z	48	613	16.4	2.64
1	X	8	492	10.95	2.23
1	Y	8	508	5.00	.98
1	Z	8	504	6.94	1.37
2	X	20	542	10.92	2.01
2	Y	20	557	10.11	1.81
2	Z	20	559	14.06	2.51

Crust color was very distinctly palest on loaves baked in Oven Z. It was slightly darker in loaves baked in X than in Y. The external development was a trifle smoother in the Z loaves than in the other two. Volumes tended to be very slightly smaller in X than either in Y or Z, although the differences are not sufficient to deserve serious consideration. All external and internal characteristics checked closely with the exception of crust color, and even here there was very little difference between Ovens X and Y. The differences in variability are not sufficient to be regarded as

of any consequence. There is justification for the general conclusion that from considerations of loaf characteristics and of variability, exclusive of other features, the evidence thus far shows no substantial basis for preferring one type of oven over the other two. Choice of ovens may perhaps ultimately depend upon other factors, among which are initial and maintenance costs, simplicity, durability, power consumption, etc.

The oven studies thus far have shown nothing to indicate that a forced draft offers any appreciable baking advantages over the natural draft, when using the rotating platform. The power consumption of Oven Y was approximately ⅔ that of X, as measured on recording meters. There are certain advantages in ovens of the Z type that are worthy of consideration. Their initial cost is low. Their capacity is small, but it is of course possible to use several of them where necessary. This offers a certain flexibility that is not possible with only one large oven. They have no top heat, which may conceivably permit of better crust color differentiation. This feature, however, should be given further study.

General Discussion

Flour 3, of higher protein content, has been the one used in by far the greater portion of these studies. This has been for the reason that flour 3 has potentialities for producing relatively large loaves, and would therefore be expected to register differences due to various methods of procedure to a greater degree than flours 1 and 2.

Geddes et al (1931) report certain conspicuous and frequently "systematic" variabilities and inconsistencies that cannot be accounted for by variations in moulding or punching the dough. During the course of these experiments here reported there were frequent occurrences that lend substantial support to the belief that "oven conditions" may justifiably be added to those factors that fail to account for the variability encountered in the oven studies. This may be clearly demonstrated without using methods of statistical analysis or biometry. When loaves were baked in pairs, where they must have been subjected to identical oven conditions, lack of concordance in loaf volume was often greater than was the case with individual loaves baked in different batches. This proves beyond doubt that the factor causing variability was certainly not the oven, despite the fact that oven variability was the specific object of investigation at the time.

On certain days all loaf volumes tended to run higher than

on other days under presumably identical conditions. This may have been due to yeast variability. On other days there was a systematic "dropping off" in loaf volume toward the end of the bake.

One cannot escape the conviction that, aside from yeast variability, the mixing operation is a far more critical factor than has generally been appreciated. This conclusion is also reached by Geddes et al (1931).

After observing the operations of such mechanical mixers as have thus far been available in these studies, one is forced to a conviction that equal thoroughness and uniformity of mixing is not ordinarily attained in the different batches, and that although moulding or oven conditions may have been the object of immediate inquiry, the variability that occurred was actually due to mixing inequalities. Mixing experiences thus far justify an opinion that the Swanson type of mixer offers greater possibilities than other mechanical types studied. The Hobart-Swanson mixing attachment is now in its final experimental stages, and doubtless will soon be perfected for handling 100 g. of flour as satisfactorily as it now handles 200 g. Further studies are contemplated as soon as it becomes available.

It is realized that many of the experiments here reported are more in the nature of "surveys" than thorough investigations. In many instances the numbers involved are too few to permit the attaching of important significance to data on variability. However, they do show certain unmistakable tendencies and trends that should serve a useful purpose in limiting the scope of the later activities in connection with the more or less complicated project that is under consideration.

The studies here reported have involved the baking of approximately 3,000 individual test loaves.

SUPPLEMENT

Experimental data obtained subsequent to the preparation of the preceding report are of a character that justify an additional brief statement. They furnish foundation for a more definite answer to certain important issues than was provided by the findings presented in the main report. They bear out the suggestion and the prediction that the mixing operation is in itself a source of variability that is likely to overshadow the other factors and operations that might conceivably contribute toward variability. The data also bring out certain tendencies in regard to types of ovens that were not so prominent in the preceding report.

Additional Mixing and Oven Experiments

The experiment involved 8 days of baking with flour No. 3 exclusively: 24 loaves were baked each day, 8 in Oven X, 8 in Oven Y, and 8 in Oven Z, giving a total of 64 loaves for each oven. The essential difference between this series and that reported in Table X of the preceding report lies exclusively in the method of mixing. The former series involved the mixing of doughs from 200 g. of flour, using the Hobart mixer with the small bowl and paddle arm. In this series, however, the modified Hobart-Swanson mixer, only, was used. Doughs from 200 g. of flour were mixed for 1 min. This was calculated, based on previous observations, to provide maximum mixing of ingredients with a minimum of "gluten development." As before, the doughs were scaled into two equal portions and baked in the three ovens, respectively.

At the end of each day's bake, the average volume of loaves baked in each oven was determined. Standard deviation and coefficient of variation were computed on each set of loaves. Table XI, which follows, presents the *averages* of these values, respectively, for the 8 days.

TABLE XI

Oven Types as Related to Loaf Volume and Variability in Loaves Mixed by the Hobart-Swanson Mixer

Oven	Number of Replicates	Mean Loaf Volume	Standard Deviation	Coefficient of Variation
		cc.		
X	64	579	12.73	2.18
Y	64	603	8.27	1.37
Z	64	598	10.15	1.70

The averages for each day, for each oven, are shown in Table XII, in order to indicate the manner in which these values fluctuate from day to day.

The data in the preceding tables, when compared with similar data for flour 3 in Table X of the main report, show definite evidence that mixing 1 min. with the Swanson type of mixer reduced variability considerably below the values secured by mixing 2 min. with the Hobart small bowl and paddle arm. This permits the oven effects to register more clearly than before. Oven Y gave the lowest average variability, and showed the least fluctuations in loaf volume from day to day. Oven X produced loaves that were distinctly smallest, lightest in weight, and darkest in crust color. Oven Z gave loaves that were decidedly palest in crust color, and they again showed a "smoother" outside development than the others. Oven Z was intermediate as to variability. Crust color

TABLE XII

VARIABILITY OF AVERAGE VALUES FROM DAY TO DAY

Date	Mean Loaf Volume	Standard Deviation	Coefficient of Variation
	cc.		
	Oven X		
5/1/31	589	11.37	1.93
5/6	584	18.01	3.08
5/7	572	10.38	1.82
5/8	578	9.89	1.71
5/11	581	11.36	1.94
5/12	591	19.78	3.34
5/13	562	6.07	1.08
5/14	580	14.93	2.57
	Oven Y		
5/1	610	2.98	0.49
5/6	596	11.88	1.99
5/7	602	11.64	1.93
5/8	607	11.57	1.90
5/11	607	5.35	0.88
5/12	600	10.74	1.79
5/13	608	4.74	0.78
5/14	596	7.27	1.22
	Oven Z		
5/1	578	10.57	1.83
5/6	602	7.67	1.27
5/7	602	10.08	1.67
5/8	602	9.12	1.51
5/11	607	10.85	1.79
5/12	592	9.65	1.63
5/13	591	11.96	2.02
5/14	592	11.31	1.91

effects produced by the different ovens were very pronounced in this series, ranging from the moderately pale crusts with Oven Z to very dark crusts with Oven X, Y being intermediate.

SUMMARY

1. Dough mixing studies involved three flours and hand mixing as compared with three types of machine mixing. The three machine mixers used were, respectively, a Fleischmann mixer, a Hobart mixer and a Swanson type mixer built by the Hobart Manufacturing Company. Machine mixing tended to produce larger loaves than hand mixing unless a restricted mixing time was used. This tendency was more pronounced with the Fleischmann and Swanson machines than with the Hobart machine, using the 3 qt. bowl and paddle-arm. Although prolonged machine mixing gave larger loaf volumes than hand mixing, due to "gluten development," it also gave greater variability. Of all methods of machine mixing tested, the lowest variability was encountered when using the Swanson mixer with a mixing time of one minute.

It apparently is not possible to establish time factors that would permit one to specify the mixing time to be used for one type of machine in order to duplicate results using another type for a definite mixing period. A time differential that serves for one flour does not necessarily hold for another.

2. Comparative studies of hand as against machine moulding involved the use of a Model G Thomson Roll Moulder. Optimum conditions for setting the sheeting rolls and the compression plate, respectively, were established by a series of experiments with different adjustments. The adjustment of the compression plate was found to be far more critical than the setting of the sheeting rolls. It was found possible with the machine to closely approximate loaf properties ordinarily produced by hand moulding. Machine moulding should tend to reduce variability, especially among different operators. It is convenient and time-saving.

3. Oven studies involved comparative tests with three types of ovens, each equipped with a revolving baking shelf and a thermoregulator. Oven X had a capacity of eight loaves, and was equipped with a fan for producing a forced draft. Oven Y was of similar capacity, but lacked the forced draft. Oven Z was a small 2-loaf oven of familiar design, with heating elements only in the bottom. The experiments were designed to furnish information on (1) comparative degree to which the ovens meet specifications as to degree and uniformity of temperature, (2) comparative effects of the different oven types on loaf characteristics, and (3) comparative influences on variability.

Temperature studies using thermocouples showed that all three ovens will satisfactorily meet the temperature specifications of the present standard A.A.C.C. baking test under conditions of ordinary laboratory operation in which loaves are introduced one or two at a time. Under certain other conditions special peculiarities were encountered, but they can be controlled.

As to comparative loaf characteristics, Oven X yielded loaves that were significantly smallest in volume, lightest in weight and darkest in crust color. Loaves from Oven Y averaged very slightly larger in volume than those from Oven Z, with crust color intermediate between X and Z, the latter giving decidedly the palest crust color.

Oven Y showed least variability among loaves in a single day's bake, and also the least daily fluctuation in average loaf volume. Oven Z was intermediate with respect to variability.

The studies showed no evidence that a forced draft in the

bake-oven offers any advantages over the natural draft when a rotating platform is used.

The introduction of an open pan of water into the bake oven did not significantly affect loaf characteristics. When bakes were made at a temperature 10° lower than specified, there was no significant change in loaf properties other than crust color.

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THE UTILITY OF MECHANICAL MOULDING IN EXPERIMENTAL BAKING[1]

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(Read at the Convention, May, 1931)

A study of the factors contributing to variability in experimental baking has interested the Associate Committee on Grain Research of the National Research Council of Canada from the time of its organization. The experimental work in connection with the various projects of the Committee is carried out on portions of the same wheat in the Universities of Alberta, Saskatchewan and Manitoba and a standard milling and baking procedure is a primary requisite for such collaborative work. While the standardization of methods has resulted in fair relative agreement between the three laboratories, wide differences in the absolute values for any given flour were obtained which greatly complicate the summarizing of the data. In view of the opinions expressed in the literature that the personal factor in moulding and panning constituted one of the major causes of variability in experimental baking, an extensive series of experiments involving 4,040 individual baking tests was recently carried out in this laboratory with the Thomson laboratory model loaf moulder, to determine its utility in experimental baking. The results have been reported in detail in a paper by Geddes, Goulden, Hadley and Bergsteinsson (1931) and only the main features will be discussed here.

Two advantages might be expected to accrue from machine moulding, namely, a reduction in the variability between replicate bakings of the same flour by any given operator, and secondly, the elimination of a considerable part of the variation between bakers. These points were borne in mind in planning the experiments. In the experimental laboratory, flours varying more widely in handling quality, loaf volume, and texture than those used in commercial bakery practice are encountered, and the machine must mould these experimental doughs without any alteration in adjustment to suit the particular characteristics of a given dough. It was, therefore, considered essential to compare the results of hand and machine moulding on doughs made from flours of varying charac-

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[2] Geddes, W. F., Goulden, C. H., Hadley, S. T., and Bergsteinsson, H. N. 1931 Variability in Experimental Baking. I. The Influence of Mechanical Moulding. Can. J. Research 4: 421-482 (1931).

teristics. For the most part commercially milled flours of varying refinement milled from hard red spring wheat were used.

In order to secure a direct comparison of hand and machine moulding the standard procedure was modified to the extent that 200 g. flour was mixed at one time. The resulting dough was divided into two equal parts by weight and these carried through the baking routine together. One dough was hand moulded and the other machine moulded and both proofed and baked at the same time. The hand- and machine-moulded doughs were thus treated as pairs and, in the statistical reduction of the results, it was possible to separate from the total variance the portion due to the operation of systematic factors which affected the pairs of loaves similarly. In most instances 50 replicate mixings were made for each flour with and without the addition of 0.001% potassium bromate. While major attention was given to variability in loaf volume, the effect of machine moulding on other bread characteristics was not entirely neglected. In each series of experiments, a number of loaves were picked at random, judged and the scores recorded.

Two series of experiments were carried out, using two different adjustments of the mechanical moulder. In the first series the sheeting rolls were set at "3" on the dial, and the depth of the compression chamber at the upper end adjusted to 1.28 in., corresponding to a depth of 1.603 in. at the exit end, the latter measurement being made vertically to the drum. In the second series the above adjustment of the compression or former plate was employed with the sheeting rolls set at "2" on the dial.

With the first adjustment, machine moulding gave, for the entire series of flours, no significant reduction in variability of loaf volume when an experienced test baker conducted the hand moulding. The machine-moulded loaves were significantly lower in loaf volume and exhibited less break and shred, greener crust characteristics, superior grain but inferior texture, and duller crumb color. The mean difference in loaf volume between the hand and machine moulded loaves baked from the different flours varied from 28 to 77 cc. or from 4.2 to 9.5% of the corresponding values for hand moulding, the difference increasing with increasing loaf volume. However, the results based on 492 pairs of loaves obtained by the same operator with the second adjustment of the moulder, which gave a better sealing of the doughs, showed a significant but slight reduction in variability of loaf volume in favor of machine moulding. The random errors expressed as co-

efficient of variability were 2.88% and 2.57% for hand and machine moulding respectively.

The depression in loaf volume, lack of boldness, coarser texture, and duller crumb color are undesirable consequences of mechanical moulding. A lower loaf volume taken by itself is relatively unimportant, but when it is considered that both the absolute and percentage differences between the hand and machine results increase with increasing loaf volume, machine moulding obviously tends to reduce the differences between flours and between the results obtained by different baking formulae. In judging bread, it is more difficult to distinguish between relative degrees of coarseness in texture than between fine silky textures. The judging of crumb color is complicated when one has "dullness" occurring with the various shades of yellow encountered in loaves baked from unbleached experimentally milled flours. The duller crumb color of the machine moulded loaves is probably associated with the coarser texture. The slight reduction in variability of replicates is offset by these undesirable features of mechanical moulding.

Our experience has been that a considerable period of training is required before a baker can secure low variability between replicates and the use of the machine would be justified if it were found that bakers with little or no experience could secure a lower variability between replicate bakings of the same flour by machine moulding. It would be expected that inexperienced bakers would mould by hand less uniformly than an experienced operator and hence that the machine would show up to better advantage when the baking was done by less experienced operators. The results, however, did not conform to this idea, since no significant reduction in the random variability of replicates was effected by machine moulding in the instance of three inexperienced bakers when the variance was corrected for the differences in mean loaf volume. In general, the less the experience of the operator the lower the loaf volumes obtained.

In the baking laboratory, comparisons between flours or methods of baking are of necessity made on the basis of results obtained on different days or at different times in the same day. Experience has indicated that there may be secular variation not only from day to day, but also during the course of any one day, and an experiment was designed to determine the extent of these variations and whether they were to be ascribed to changing disposition in moulding. Using one flour and the simple (basic) form-

ula, 50 pairs of loaves were baked on each of five consecutive days. The pairs of loaves consisted of one loaf moulded by hand and one by machine for each of 50 replicate double mixings, the consecutive pairs of loaves being placed in the same position in the fermentation cabinet each day.

The range between the daily means was 18.4 cc. and 27.4 cc. for hand and machine moulding respectively. Furthermore, when the days were arranged in order of increasing loaf volume the same order was obtained for hand and machine moulding, indicating that some systematic factors were operating which affected both the hand and machine results to almost the same extent. Assuming that the mechanical moulder produced perfect uniformity in its portion of the experiment, the day differences cannot be ascribed to variations in the manual manipulation of the doughs during moulding. Definite trends in loaf volume were observed within each day, but were not alike on different days with the exception of a more or less uniform tendency for the last loaves baked to be lower in loaf volume. These trends persisted in the machine results and were more marked on some days than others. The trend curves for the five days combined deviated but slightly from the mean values and, since the loaves for the corresponding intervals for each day were placed in the same positions in the cabinet and oven, there was no definite indication of any constant localized differences attributable to place differentiation in the cabinet. Secular variation is an important factor in experimental baking and is apparently not due to lack of uniformity in hand moulding. Our experiments have not thrown any light on the causal factors. The results obtained may have been due to variations in mixing, lack of uniformity in the yeast, or to variations in the handling of the dough during punching. The temperatures of the mixed doughs and of the baking cabinet and oven were carefully controlled and, while small fluctuations in temperature might conceivably be in part responsible for secular variations within days it seems altogether improbable, in view of the control exercised, that temperature variations were responsible for the daily differences.

While variations in the manual manipulation of doughs by any one operator are apparently relatively unimportant in relation to the sum total effect of other factors causing variability between replicates, our data indicated that "moulding personality" was a factor contributing to the differences between bakers. The results of an experiment conducted to determine the relative importance of punching and moulding as causal factors in producing variability

between bakers are deemed of sufficient interest to reproduce them in part here.

Using one flour and the simple or basic formula 200 loaves were baked on each of three consecutive days, four bakers of varying experience designated as A, C, D, and E being employed. The scheme for one day's bake was as follows:

Series A. 50 double mixings	50 loaves A punching, C moulding by hand 50 loaves A punching, C moulding by machine
Series B. 50 double mixings	50 loaves C punching, C moulding by hand 50 loaves C punching, C moulding by machine

The above scheme was repeated with bakers D and E. Baker A was used in punching the doughs for the other bakers because of his greater experience.

The influence of moulding individuality may be ascertained by a comparison of the hand and machine results obtained by C, D, and E when A did the punching. For machine moulding, with A punching, the different bakers contributed only to the extent of putting the doughs through the machine and placing the moulded doughs in the pans. On the other hand, the influence of punching personality may be ascertained by a comparison of the results obtained by A punching and C, D, or E moulding with C, D, and E punching and moulding respectively. With A punching, the time of C, D, and E was not so fully occupied and there is a possibility that they put more conscious effort into the work of hand moulding than when they also had to punch the doughs. In view of this possibility, the machine results form the best basis for a consideration of punchng individuality.

The mean loaf volumes in cc., each based on 50 loaves, are recorded in Tables I and II.

With regard to moulding personality, it will be observed that the range between the mean loaf volumes obtained by the three bakers with A punching was reduced from 40.1 cc. for hand moulding to 8.7 cc. for machine moulding, indicating that moulding personality is an important factor contributing to the differences in mean loaf volume obtained by different bakers. It is also obvious that individuality in punching is not without influence.

These results are very striking particularly in regard to D. It will be noted that the only case in which baker D obtained results comparable with either of the other bakers was when A punched the dough and D merely placed it in the machine for moulding. The values for this operator shown in Table III are, in fact, in ascending order according to the amount of manipulation that he performed on the dough.

TABLE I

EFFECT OF MOULDING PERSONALITY

(Mean Loaf Volumes on 50 Loaves)

Baker	A Punching	
	C, D or E Hand Moulding	C, D or E Machine Moulding
	cc.	cc.
C	596.2	578.2
D	626.7	571.0
E	586.6	569.5

TABLE II

EFFECT OF PUNCHING PERSONALITY

(Mean Loaf Volumes on 50 Loaves)

	Baker C	Baker D	Baker E
Results by Machine Moulding			
	cc.	cc.	cc.
A punching, C, D or E moulding	578.2	571.0	569.5
C, D, or E punching, C, D, or E moulding	562.8	589.3	558.8
Difference (A-C, D or E)	+15.4	−18.3	+10.7
Results by Hand Moulding			
A punching, C, D, or E moulding	596.2	626.7	586.6
C, D, or E punching, C, D or E moulding	586.6	635.6	574.3
Difference (A-C, D or E)	+9.8	−8.9	+12.3

TABLE III

	Mean Loaf Volume in cc.
A punched, D moulded with machine	571.0
D punched, D moulded with machine	589.3
A punched, D moulded by hand	626.7
D punched, D moulded by hand	635.6

TABLE IV

	Range in Mean Loaf Volume in cc.
C, D & E, punching C, D, & E, moulding by hand	61.3 cc.
A punching, C, D, & E, moulding by hand	40.1 or 21.2 cc. (reduction in range due to removal of punching personality.)
C, D, & E, punching & C, D, & E, moulding by machine	30.5 or 30.8 cc. (reduction due to removal of moulding personality.)
A punching, C, D, & E, moulding by machine	8.7 or 52.6 cc. (reduction due to removal of punching and moulding personality)

The relative importance of punching and moulding personality in producing variability between bakers may be shown by comparing the ranges in mean loaf volume when these variables are successively eliminated. These values are recorded in Table IV.

These data indicate that individuality in moulding has a somewhat greater effect on the results than punching personality, and that, if the influence of both variables could be removed, the mean loaf volumes obtained by different operators in replicate bakings of the same flour would agree very closely. It should be pointed out that operators of widely varying experience were purposely used and the range between their results may be greater than would be obtained in the instance of experienced bakers.

In conclusion, hand moulding does not appear to be a factor of major importance in causing variability between replicate bakings. Since punching and moulding personality both contribute to the variability between bakers, the introduction of mechanical moulding may be expected to reduce but not eliminate the large differences in mean loaf volume which different operators working in the same or different laboratories secure in replicate bakings of the same flour. The manual manipulation of doughs during moulding is not a factor of such great importance as has been commonly supposed by workers in this field and much detailed work yet remains to be done in elucidating and eliminating the factors responsible for variability before the accuracy of the experimental baking test can be brought within desirable limits.

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A SUPPLEMENTARY PROCEDURE WITH THE BASIC BAKING TEST FOR USE WITH LOW DIASTATIC FLOURS[1]

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(Read at the Convention, May, 1931)

During the baking of flours experimentally milled from the wheat variety samples of the 1930 crop received from the Division of Agronomy and Plant Genetics of the University of Minnesota it was found that certain of these samples were extremely low in their ability to produce gas during fermentation when baked by the usual procedure in use in the cereal laboratories of the Division of Agricultural Biochemistry. The flours milled from wheats grown in the western portion of the State of Minnesota in 1930 were especially deficient in gas-producing ability.

The baking procedure ordinarily used in these laboratories, which will hereafter be referred to as the "usual baking procedure," is based upon the official baking procedure of the A. A. C. C. as reported by Blish (1928) and Werner (1925) with certain supplements which experience has shown to be desirable. Absorption is regulated to produce doughs of as nearly the same plasticity as possible. In the testing of wheat varieties it appears that the water-imbibing power is variable, and in order to put the tests upon a comparative basis it is necessary to vary the water added. Mixing is done in a Hobart mixer, using the paddle blade in the three-quart bowl for fifteen seconds on slow, and one minute on high speeds. Moulding is done by hand on a piece of canvas belting rather than on a board as specified in the basic procedure.

The flours milled from western Minnesota wheats possess all the characteristics of extremely low diastatic flours. When baked in the usual manner, fermentation proceeded normally for the first two hours; then there was a decided falling off in the amount of gas produced. In many cases there was practically no increase in dough volume during pan proof. The oven spring in these samples was fairly good, but as the dough volume was small the resulting loaf volume was likewise small, in many cases below 300 cc. The crust color was nearly always very pale, which has been noted by Blish and Sandstedt (1927), and by Blish, Sandstedt, and Platenius (1929), to be correlated with a deficiency in the diastatic power of the flour. The loaves were frequently rough and ragged

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in appearance, their texture was usually very firm and non-resiliant, their grain small, but large ragged holes were often present.

Flours milled from eastern and southern Minnesota wheats exhibited these characteristics to a less degree, but still produced unsatisfactory bread. Both the spring and the winter wheats of the 1930 crop yielded flour that was deficient in diastase. This condition appears to be a property of the flours and not a fault in baking technic, as samples of Kansas and Canadian flours gave very satisfactory bread by the usual procedure.

The use of bromate and also of phosphate failed to effect the desired improvement. High diastatic malt extract brought the loaf volume up to normal, but the accompanying proteolytic activity of the malt extract impaired the color, grain and texture of the crumb. The work of Sherwood and Bailey (1926) showed that flour milled from sprouted wheat is a satisfactory source of diastase for use in supplementing diastase deficiencies. A series of flours recently milled from wheat sprouted for varying lengths of time was available, and a number of preliminary tests were made with this material. It was found that substituting 3% of flour milled from wheat sprouted for three or four days, for a like amount of the flour under test, would compensate for the deficiency in diastase of the latter. Accordingly the three day sprouting period was used in all work.

The sprouting procedure was fairly simple. A 1,000 g. portion of sound wheat was placed in a shallow pan and mixed with sufficient water to stimulate germination, usually about 600 cc. The pan and contents were then placed in a closed air-thermostat maintained at about 27° C. for three days. The wheat was turned frequently, care being taken to prevent molds from developing. At the end of three days the wheat was spread out on a table and dried rapidly with the aid of an electric fan at ordinary temperatures. After drying, a straight grade flour was milled from the sprouted wheat.

The use of only 3% of the high diastatic flour resulted in normal bread from the same flours that had yielded extremely unsatisfactory bread by the usual baking procedure. All phases of the usual baking procedure were unchanged, with the exception of water absorption which had to be lowered slightly in the case of the modified procedure using the sprouted wheat flour. The loaves by the diastase method were frequently twice the size of the loaves baked from the same flour by the usual baking procedure. In no case did the use of the diastatic flour fail to increase loaf volume.

In a series of 17 flours milled from wheats grown at Morris station in central western Minnesota, the average loaf volume was increased from 337 cc. by the usual method to 567 cc. by the use of the sprouted wheat flour. This was an increase of 68%. A similar series from Crookston in the northwestern portion of the state resulted in loaf volumes averaging 357 cc. by the usual method and 532 cc. by the use of the high diastatic flour. This was an increase of 49%.

Figure 1 shows cross sections of loaves baked from four of the strong spring wheat flours milled from wheat grown at Morris, Minnesota. The increase in loaf volume is readily apparent to the eye. It is of interest to note the large ragged holes in the two lower loaves baked by the usual baking procedure. These holes are absent in the accompanying loaves from the same flours baked by the modified high diastatic procedure. Grain and texture of the crumb are much improved by the use of the modified procedure. Color of the crumb is lighter in the case of the high diastatic loaves than in the loaves baked by the usual baking procedure. This is not alone due to the change in grain, but is evidenced in the doughs after about three hours fermentation. Crust color is a rich golden brown in the loaves baked with diastase, and the contour of the loaves is likewise good.

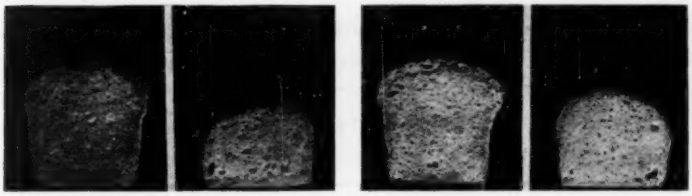
Figure 2 shows similar comparisons. In the upper left hand corner are two loaves from flour of Marquis wheat also grown at Morris, Minnesota. The improvement in the Marquis wheat is self-evident, and as Marquis is the standard bread wheat of the spring wheat area, it is shown here very plainly that this modified procedure was absolutely essential in judging these varieties from a baking standpoint. In the upper right hand corner is bread made from flour milled from Minturki winter wheat. This flour showed the same improvement by the addition of sprouted wheat flour as did the spring wheat flours. In the lower row are pictures of two Marquis-Minturki hybrids of winter habit which were also naturally low in diastase in the crop of 1930.

The observations of Mangels (1926) and others makes it appear that diastatic activity in closely related Vulgare wheats is probably a function of environment and is more or less uniform between varieties when environment is identical. It does not seem to be an inheritable character, except possibly between species.

In variety studies of wheat it is essential that comparisons be confined to samples grown under identical environmental conditions. Ordinarily this will result in wheat samples which vary only

Figure 1

MARQUILLO MARQUIS X KANRED



With Diastase Usual Method With Diastase Usual Method

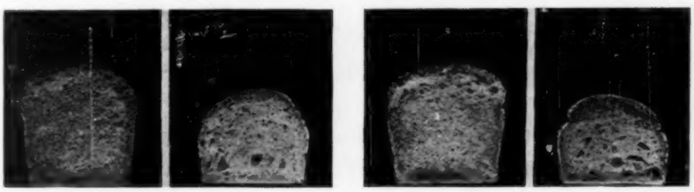
DOUBLE CROSS

2303 2305

With Diastase Usual Method With Diastase Usual Method

Figure 2

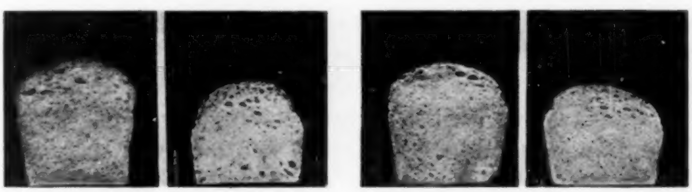
MARQUIS MINTURKI



With Diastase Usual Method With Diastase Usual Method

MARQUIS X MINTURKI

II-22-38 II-22-49



With Diastase Usual Method With Diastase Usual Method

within relatively narrow limits. If these conditions are not met the results may be very misleading, as can be shown by the data obtained in this investigation. If all 154 samples be considered as a unit, there is a range of 5.3% in wheat protein with a standard deviation of 1.52%. The coefficient of correlation between protein in wheat (a) and loaf volume by the usual baking procedure (b) is $r_{ab} = -.20 \pm .05$, and between protein and loaf volume by the modified diastatic procedure (c) is $r_{ac} = + .74 \pm .02$. Both of these are statistically significant correlations, but they are unjustifiable because of there being three major variables involved instead of only two. Environment is the third variable. When environment is eliminated as a variable the results are very different. In the group of 48 spring wheat samples from the rod row trials, environment is essentially the same for all samples as replications take care of soil heterogeneity, and the plots of ground covered by the rod row tests are small enough for other environmental factors to be uniform. In this group the range in protein is only 1.0% with a standard deviation of only 0.37%. In this case the coefficient of correlation between protein and loaf volume by the usual baking procedure is $r_{ac} = - .09 \pm .09$, and between protein and loaf volume by the modified method is $r_{ac} = + .21 \pm .09$. Neither of these correlations are statistically significant.

The low correlation between protein and loaf volume by the diastatic or modified method for the rod row series was not due to both protein and loaf volume being in narrow ranges as there was a range in loaf volume of 263 cc. which is certainly a significant variation. The significant differences in loaf volume in this series are considered to be due principally to factors carried in the genetic constitution of the individual wheat varieties, as protein content and environment during the growing period are essentially uniform for the series, and sufficient diastase has been provided so that these inherent factors can be expressed.

Summary

In comparing the baking values of different flour samples there are two types of variables which must be considered. These are, first, those variables which are carried in the genetic constitution of the variety of wheat from which the sample of flour has been milled, and, second, those which are quantitatively varied in consequence of environment. As each variable influences the expression of nearly every other variable, it is essential in any comparative baking tests to eliminate as many variables as possible other than the one under consideration.

The factors which are quantitatively varied by environment can generally be grouped into two classifications. The first is the chemical composition insofar as it is subject to environmental control. In this study protein content was used as an index of the chemical composition, but it is only one variable of many in this class. The second major group includes enzymic activity. In the production of yeast-leavened bread, diastase must be present in sufficient concentration if a normal product is to be obtained. It is now possible to raise wheat for comparative variety trials in such a manner that these environmental variables will be held within narrow limits in a series under study. A method is proposed in this paper for furnishing sufficient diastase in a satisfactory form to eliminate in some degree diastase deficiency as a limiting factor in baking studies.

It is only when the chemical composition, as measured by protein content and other such measures, is uniform, and there is sufficient diastase present to allow a normal fermentation, that accurate study can be made of the differences in the baking qualities of flours due to the factors carried in the genetic composition of the corresponding wheats.

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REPORT OF THE COMMITTEE ON METHODS OF ANALYSIS

J. T. Flohil, Chairman

Pillsbury Flour Mills, Minneapolis, Minnesota

(Read at the Convention, May, 1931)

The membership of this committee consists of F. A. Collatz, W. C. Meyer, A. E. Treloar and J. T. Flohil, all of whom functioned during 1929-30, and two new members—D. A. Coleman and A. W. Meyer.

It has been the policy of the present committee to continue the work undertaken by the previous committee. However, no claims are made that the matter under investigation has been fully disposed of, and we must leave it to the judgment of the Convention as to what extent we have been successful.

In the first place it will be in order to state that we deviated from the policy of last year's committee in that the individual members have now been made responsible for the work assigned to them by the chairman, who in turn assumes responsibility for the choice of the subjects here presented. It is the opinion that this change in policy affects the quality of the work more favorably and thereby benefits the Association, and in addition insures full credit to the individual member for the work assigned to him.

As has already been stated, the work of this committee has aimed to represent an extension of last year's research. In addition to this we have been able to add a new feature, thanks to the presence of Mr. A. W. Meyer in this year's committee. Mr. Meyer's experience with the analytical control of baking ingredients, practiced for years in the W. E. Long Laboratories, has been made available for our association.

The assignments for this year were as follows:

The Direct Ash Method	W. C. Meyer
The Chemical Analysis of Some Important Baking Ingredients	A. W. Meyer
Acidity of Alcoholic Flour Extracts	F. A. Collatz
Moisture Determination in Wheat with Special Reference to Quick Methods	D. A. Coleman
Protein and Moisture Determinations in Wheat with Special Reference to Conditions Governing Preparation of Samples for the Analysis	J. T. Flohil
Statistical	A. E. Treloar

Owing to heavy demands on his time, F. A. Collatz was not able to fill his assignment. A. E. Treloar in his capacity as biometrician was not assigned a special task but was held available for the benefit of the other members who might have wished to

consult him as regards data which lent themselves to statistical treatment.

The individual members who prepared papers covering the subjects assigned as noted will now be asked to present them.

Protein and Moisture Determinations in Wheat with Special Reference to Conditions Covering Preparation of Samples for Analysis

J. T. Flohil

The work here presented attempts to account for some very general and persistent discrepancies in the comparative results obtained in the moisture and protein determination to which reference was made in the report of the previous committee (Flohil, 1930). That report discussed only statistical data and no attempt was made to account for the causes of analytical differences.

TABLE I

Percentage Accuracy of Collaborative Protein and Moisture Determinations, 1929-1930

Test Material	Per Cent Deviation from the Average	
	Protein Determinations	Moisture Determinations
Flour	89% within 0.1%	77% within 0.1%
Wheat ground by distributor	84% within 0.2%	69% within 0.2%
Wheat ground by collaborator	71% within 0.2%	56% within 0.2%

From the 1930 report it appears that the accuracy of protein determinations on flour is of a considerably higher order than that on wheat samples, especially when the wheat is ground by the individual collaborator.

These differences in accuracy in the case of flour and grain analysis are accounted for by the fact that the preparation of the sample of wheat for the analysis is a source of error, while in the case of flour the sample is ready for analysis.

Securing a Representative Sample

Before going into the details relative to sources of error in making moisture and protein determinations on wheat it will be helpful to describe briefly the procedure now generally accepted for obtaining a sample of grain which must represent physically,

as well as chemically, the entire lot, and to point out where car sampling and reducing the sample to a workable size may introduce error. Although no special reference will be made to the technique of sampling car lots of grain, this manipulation is of major importance and well deserves the attention of a future Methods Committee. The sample as taken from the car usually weighs about 5 to 6 lbs. No chemical or physical determinations should be made on such a sample until it is properly cleaned by the removal of what is usually called "dockage." Dockage covers a wide range of foreign material as weed seeds, sand, weed stems, chaff and other grains than wheat. To reduce the size of the gross sample several devices are in use such as those recommended in U. S. Dept. of Agriculture Bulletins 287 or 857. The Fisher Scientific Company also describe "A Good Mixer" in their publication, The Laboratory, **4**: 29 (1931). It appears from previous investigations that a 30 to 40 g. sample is the proper size to grind for analytical purposes.

Grinding the Sample

It is quite essential that the sample be ground previous to analysis. This can be seen from the following experiment. A sample of wheat was ground in the approved manner and its protein content determined in triplicate. This was found to be 13.05%. Sixteen lots of whole kernels were taken from the same sample of wheat and their protein content determined. The protein content of the individual lots was as follows: 13.30%, 13.00%, 12.70%, 13.00%, 12.90%, 12.70%, 12.90%, 12.80%, 12.90%, 13.00%, 12.60%, 13.40%, 13.40%, 13.30%, 13.00% and 12.80%. The average protein content of the 16 samples was 12.98%. The variation in protein content was 1.6%. It is very evident, whether we take the average value for the 16 individual tests as correct, or whether we take the 13.05% value of the ground sample as the correct value that the making of protein tests on unground material will result in serious inaccuracies. Grinding greatly reduces these inaccuracies by making possible a near uniform sample.

It must not be concluded, however, that by grinding an entirely uniform mass results, as the degree of uniformity is dependent upon and is coincident with fineness of grinding, and even with material ground to that degree of fineness usually thought sufficient for analytical work, the protein content of the various sized particles in the mass is not uniformly the same throughout. To illustrate this point an analysis of the protein content of the frac-

tional parts of two samples of wheat, one ground coarsely and the other ground to the usual degree of fineness is given in Table II.

TABLE II

PROTEIN CONTENT OF FRACTIONAL PARTS OF GROUND WHEAT SAMPLES

Sample Ground Coarse		Sample Ground Fine	
Per Cent Ground Material Remaining on or Passing Thru the Designated Sieve	Per Cent Protein in Fraction	Per Cent Ground Wheat Remaining on or Passing Thru the Designated Sieves	Per Cent Protein in Fraction
9.5% on 24 wire	13.30	29.0% on 60 GG	13.90
9.5% on 30 wire	13.20	31.0% on 9XX	12.10
5.0% on 36 wire	12.50	7.5% on 10XX	12.40
25.5% on 60 GG	11.50	3.0% on 11XX	12.50
13.5% on 9XX	11.70	3.5% on 12XX	12.30
37.0% thru 9XX	13.70	26.0% thru 12XX	13.40

The protein content of the coarsely ground wheat was 12.50%. The extreme variation in protein content of the various particles within the ground wheat sample was 2.20%. Twenty-five and five-tenths per cent (25.5%) of this coarsely ground wheat had a protein content as low as 11.50%, while 37.0% of the sample contained particles having 13.70% protein. From the percentage of protein found in the several fractions, it will be seen that there is no relation between fineness and protein content as the intermediate fractions were lower in protein content than the coarsest or finest. This phenomenon was also observed in the instance of the sample ground fine.

The principal object, therefore, of grinding to a certain degree of fineness is to obtain, insofar as possible, the proper homogeneity necessary for obtaining a sample that is truly representative of the mass. Fineness of grinding in turn is limited by other conditions which will now be discussed.

The grinding of a sample to a fine powder entails a serious source of error in moisture-containing substances such as grain. The loss in moisture content incident to the reduction to a fine state of subdivision disturbs the relation between the protein content of the ground sample and the protein content of the sample before grinding.

Heat of friction in the attrition type of grinder intensifies this loss of moisture.

In a general way it can be said that loss by evaporation depends upon the following factors: the moisture content of the wheat before grinding; temperature conditions in the laboratory, as well as in the grinder; the relative humidity of the air; and the time of exposure to all of these conditions.

Simple mathematical computation will show the importance of the loss of moisture on the relative protein content of the ground and the unground samples. Obviously the greater the protein content of the wheat, the greater the protein error caused by the evaporation of moisture. This fact, apparent as it is, is often overlooked. The data shown in Table III illustrates this quite clearly.

TABLE III

CHANGE IN PROTEIN CONTENT AS INFLUENCED BY MOISTURE LOSSES

Amount of Evaporation Per cent	Protein Content Per cent					
.0	18.00	16.00	14.00	12.00	10.00	8.00
.2	18.04	16.04	14.03	12.03	10.02	8.02
.4	18.07	16.06	14.05	12.05	10.04	8.03
.6	18.11	16.10	14.08	12.07	10.06	8.05
.8	18.16	16.14	14.13	12.11	10.09	8.07
1.0	18.20	16.17	14.15	12.13	10.11	8.09

Losses of moisture resulting from the grinding process frequently run as high as 0.5% to 1.0%. This in terms of protein on an 18% protein wheat means a positive error of 0.1 to 0.2%. Errors of this order are material and their importance should not be overlooked.

We have noted the very considerable deviation in the moisture results reported by the Association members in our previous report on samples tested by individual members. Thirty-four per cent (34%) of the reported results were outside of a range 0.3% below and 0.3% above the average, or a total range of 0.6%. Although some of the variations undoubtedly are caused by errors in the technique of the moisture determination itself, the greatest deviation arises from the preparation of the sample for analysis, namely, the grinding process. In the case of the moisture determination the percentage error caused by evaporation is very considerably larger than in the case of the protein determination. Heat generated by the grinding machine, low relative humidity in heated laboratories during the winter months, and prolonged contact of the ground material with the air, are, as we have already seen, the main causes of the loss of moisture in the sample and therefore are responsible for low moisture results. All these reasons are very evident and hardly require further confirmatory proof.

We here present a series of moisture determinations on subsamples of the same wheat sample on successive grindings, beginning with a cold Arcade grinder, so as to demonstrate the influence of the gradual heating of the grinder on the moisture results. This

is a factor which can be and must be controlled through the prevention of the heating of the grinder.

TABLE IV

EFFECT OF TEMPERATURE RISE OF GRINDER ON MOISTURE CONTENT OF SAMPLE

Number of Grindings	Temperature of Ground Sample	Moisture	Number of Grindings	Temperature of Ground Sample	Moisture
		%			%
1	28° C.	16.05	9	36°	15.80
3	30° C.	16.05	11	40°	15.20
5	33° C.	15.90	13	40°	15.15
7	35° C.	16.00	15	43°	14.75

It is a general practice to catch the sample of ground wheat as it comes from the grinder, in a container in which it is kept sealed until needed for the analysis. Especially in the case of high moisture wheats and tempered wheats, the air in the container is practically saturated with moisture, and condensation of moisture on the inside of the container's surface may easily occur when the sample is transferred to colder surroundings. It is easy to see that the moisture equilibrium in the sample is thus destroyed, resulting in serious errors in the analysis.

Although not entirely pertinent to the subject matter, we may on account of its close relation, briefly refer to the weighing of the charge; first as regards the protein determination. The finer the ground sample, the easier it will be to obtain a representative sample of the weight of about 1 g., the usual size of the charge. Especially in the case of high moisture grains, it is extremely difficult to obtain the desired fineness, and special care must be taken that the charge shall represent the different fractions of the wheat as regard fineness in the proportion as they occur in the sample. Shaking of the sample to this end is absolutely inadvisable, as the larger particles tend to come to the surface and the finer particles collect at the bottom of the container. Careful stirring with a rod will produce best results. It was found that in a series of ten samples run with these two mixing methods, the average of the shaken sample was about 0.15% lower than the average on the stirred sample and the uniformity in results of the latter was of a much higher order than the former. In the case of the moisture determination the same precautions must be taken as for the protein determination. In addition special care must be taken in reference to loss of moisture during weighing, which will greatly depend on the actual moisture content of the wheat, the relative humidity in the weighing room and last but not least the time of

the weighing procedure. In grain analysis it may be said that it takes as much careful work to obtain and prepare a representative sample as it does to analyze it. This is undoubtedly true, and this paper, although not offering any new viewpoints, may have its value in that it emphasizes and elucidates certain conditions pertinent to correct practice, without which no accurate work is possible.

Ashing Methods

W. C. MEYER

Last year the Methods Committee recommended that further consideration be given to the study of the so-called direct ash method for determining the ash content of flour. As a result of the determinations made last year, on various types of flour selected from mills located in different parts of the United States, it was quite generally agreed that the method was accurate.

The work this year has been a repetition of last year's program, including in addition the application of the direct ash method to soft wheat flours. The use of oxygen as a means of hastening the ash determination was also studied. In this connection ashing comparisons were made by the indirect as well as the direct method.

Ash Results by the Direct Ash Method

Collaborative Studies.

In August, 1930, a request was made to each section chairman that they have a direct or an indirect ash determination, as the situation might warrant, made on one of the collaborative samples sent out to their section members during the year. This request was made, not only to save time and expense, but also to acquaint each section member with the direct ash method. Although the general response was not so good as was expected, several sections complied, furnishing valuable data. Due to the length of the various sectional reports the results of the collaborative tests have been condensed and presented in Table I.

The results speak for themselves, indicating a high degree of accuracy in the hands of each section.

Soft Wheat Flour Studies

Ten soft winter wheat flours and five hard winter wheat flours were ashed in the referee's laboratory by the indirect and direct

TABLE I

COMPARISON OF RESULTS OBTAINED BY ASHING FLOUR BY THE DIRECT AND INDIRECT METHODS

Report	Number of Collaborators	Per Cent Ash[1] by	
		Indirect	Direct
1	16	0.580	0.580
2	16	.940	.950
3	24	.401	.397
4	10	.477	.480
5	5	.447	.440
6	6	1.125	1.222
7	21	.672	.673
8	10	.503	.498
9	22	.490	.490
10	22	.430	.430
11	7	.783	.784
12	6	.386	.388

[1] Results reported are sectional averages.

methods. Vitreosil crucibles were used, and ashing took place under pyrometric control, overnight at 550° C. The results obtained are shown in Table II. An examination of the data in this table will again convince one of the high degree of accuracy obtainable by use of the indirect ashing method.

TABLE II

COMPARISON OF ASH RESULTS BY DIRECT AND INDIRECT METHODS ON SOFT AND HARD WHEAT FLOURS[1]

	Indirect Method %	Direct Method %
1 Soft winter	0.370	0.370
2 Soft winter	.551	.550
3 Soft winter	.380	.379
4 Soft winter	.402	.404
5 Soft winter	.350	.347
6 Soft winter	.451	.452
7 Soft winter	.360	.362
8 Soft winter	.350	.351
9 Soft winter	.382	.380
10 Soft winter	.403	.400
1 Hard winter	.450	.452
2 Hard winter	.402	.400
3 Hard winter	.419	.417
4 Hard winter	.651	.653
5 Hard winter	.969	.966
Average	0.4592	0.4589

[1] Results are averages of two determinations.

In connection with the direct ash method it was found that vitreosil, platinum, or silica crucibles work better than porcelain in that ash does not stick to these crucibles and can be dumped on

the scale pan more easily. However, it was learned that approximately 75% of the collaborators reporting on the direct ash method used porcelain crucibles. In these collaborative studies it was also of interest to learn of the wide variation with regard to ashing temperature and ashing time used by the various collaborators. A range of from 6 hrs. at 430° C. to overnight at 580° C. was reported.

Ashing Results by the Oxygen Method

Description of manner of making test: Two gram samples of flour were weighed into vitreosil crucibles 25 mm. in diameter and 20 mm. deep. Oxygen was introduced into the furnace by means of a brass tube. The amount of oxygen was regulated by passing the gas through an inverted thistle tube under water and counting the bubbles per minute. Temperature and pressure are very important, the one depending upon the other. In this work temperatures of 490° C. to 540° C. were used. At the beginning of the investigation with regard to the oxygen method, the crucibles were first placed into a furnace not equipped for use of oxygen at a temperature of 430° C. and burned for 45 min. The crucibles were then transferred to a furnace equipped for use of oxygen

TABLE III

COMPARISON OF ASH RESULTS, OXYGEN METHOD VERSUS DIRECT AND INDIRECT ASH METHOD

Sample Number	Indirect Method Over-night	Direct Method Over-night	Oxygen Applied to Indirect Method	Oxygen Applied to Direct Method
	%	%	%	%
1 Soft winter	0.440	0.435	0.44	0.445
2 Soft winter	.435	.435	.435	.435
3 Soft winter	.405	.400	.405	.405
4 Soft winter	.435	.435	.435	.435
5 Soft winter	.405	.405	.410	.410
1 Hard winter	.660	.655	.660	.650
2 Hard winter	1.020	1.020	1.010	1.020
3 Hard winter	.460	.465	.460	.465
4 Hard winter	.450	.450	.450	.455
5 Hard winter	.490	.485	.490	.490
6 Hard winter	.980	.980	.990	.995
7 Hard winter	.485	.480	.485	.485
8 Hard winter	.980	.985	.995	.985
9 Hard winter	.385	.385	.390	.385
10 Hard winter	.660	.655	.655	.660
Average	0.5793	0.5780	0.5806	0.5813

and incineration completed in 2½ to 3 hrs. at 510° C. It was later found that just as accurate results could be obtained if the crucibles were immediately placed into the oxygen furnace with the applica-

tion of a small amount of oxygen after incineration was complete, continuing burning at a temperature of 490° C. for 40 min. At the end of this period the oxygen supply is increased, likewise the temperature, to 540° C. By this procedure it is possible to obtain results within 2 to 2½ hrs. A higher temperature seems to flatten the ash and in many cases a hard core will remain that is very difficult to burn out.

The results obtained by the oxygen method of ashing are given in Table III. The results obtained by this method compare very favorably with results obtained by overnight ashing by either the indirect or direct method. It would seem as if it was possible to obtain ash results by the oxygen method in approximately 2 hrs. time. However, much greater care must be exercised when the oxygen method is used.

MOISTURE DETERMINATIONS IN WHEAT WITH SPECIAL REFERENCE TO QUICK METHODS [1]

D. A. Coleman

Bureau of Agricultural Economics, Department of Agriculture, Washington, D. C.

(Read at the Convention, May, 1931)

Without doubt, the development of methods and devices which materially shorten the time necessary to make any analytical determination relating to cereals, is of interest to the cereal chemist. This is particularly true with regard to the moisture determination which is made so frequently. Such devices and methods become increasingly important if, in addition to their time-reducing characteristics, they also make possible the curtailment of the routine of moisture testing, reduce the cost of making the test, make possible a reduction in occupied laboratory space, as well as partially eliminate the necessity for expensive laboratory equipment such as balances, ovens, etc.

During the past two years there have been developed several moisture testing devices designed to accomplish the purposes first mentioned. All of these devices are spoken of as instantaneous in their action, and are claimed to give results of high accuracy.

As is usual, when means for rapidity of action is sought, the field of physical chemistry is invaded, and as a result the apparatus

[1] This paper was read as a sub-report of the Committee on Methods of Analysis.

on the market today is classified into two distinct types of electric moisture testing equipment. Oddly enough, both types of equipment did not originate in the minds of those primarily interested in grain, but were the outgrowth of research on the part of other industries, particularly the lumber industry, which was in need of a simple and reasonably accurate means of ascertaining the moisture content of the materials that were being processed.

At the present time there are five electric moisture testers available for sale and/or test. They are the Burton-Pitt apparatus, a Canadian invention (Burton and Pitt, 1929); the German "D-K" device—"Schnellwasserbestimmer," foreign made (Berliner and Rüter, 1929); the Dielectrometer, made in Kansas City; the Limbrick device, a Canadian invention; and the Heppenstall moisture meter for grain (Coleman, 1930). Designation is made of the last device specifically for grain, as there is also a Heppenstall moisture meter for wood and for tobacco.

The first three instruments mentioned are basically of one type, i.e., wired with specially aranged radio tube circuits in which an alternating current of high frequency is supplied by means of storage batteries and radio tubes. For certain critical values of the inductance and capacity of the electric circuit the strength of the current is modified when foreign materials are inserted into the condenser. These modifications are controlled by the dielectric properties (i.e., ability of the foreign materials to hold an electrostatic charge) of the substance under test. Water, for instance, has a dielectric constant of approximately 80, whereas the dielectric constant for starches, sugars, proteins, and celluloses found in cereals is less than 10.

The last two devices—the Limbrick device and the Heppenstall moisture meter—operate on the conductivity principle.

During the past two years comparative tests have been made relative to the efficiency of three of these moisture testers, namely, the German D-K device, the Dielectrometer, and the Heppenstall moisture meter for grain.

Choice of Standard Method

In making accuracy comparisons, one is immediately confronted with the problem as to what method to use as the reference or standard test. Under the United States Grain Standards Act, all moisture tests relative to the grading of grain must be made by the Brown-Duvel method (Boerner, 1929), the officially recognized substitute for the water-oven method. However, amongst the great majority of cereal chemists, the Brown-Duvel

method is in disfavor, and as a result many have adopted the 130° C. air-oven method as perfected for flour as the standard method of making a moisture determination on wheat.

The reasons for the abandonment of the Brown-Duvel method by the cereal chemist may be stated in part as follows: first, this method does not lend itself to the accuracy demanded in present day mill control, in that by its use the raw material, wheat, is purchased on one standard of moisture testing, and the major processed material, flour, is merchandised on a different standard of test; further, it has apparently not been possible to work out a suitable factor to convert the results of one test into terms of the other. Again, because of the emphatically empirical character of the Brown-Duvel method, it offers operative difficulties in the matter of securing accurate and consistent test results when tests are carried out by several individuals.

It thus appears that the only method for testing moisture in wheat which is official in character is not wanted by the rank and file of cereal chemists, and the tendency is to use in its place the 130° C. air-oven method, official for flour (Book of Methods, 1928). This action, at once, brings to the foreground the question as to whether the method for flour moisture, i.e., the 130° C. one-hour air-oven method as applied to wheat, gives consistent and accurate results when compared with the vacuum oven method as a standard.

Space will not permit going into the details relative to the comprehensive research that took place to answer this question. Let it suffice to say that with all classes of wheat, the 130° air-oven method, official for flour, gives moisture test results with an accuracy of $\pm .1\%$, when compared with the 5-hour vacuum oven test as the standard. For the purposes of this Association, therefore, the 130° C. air-oven test was selected as the basis on which to make the various comparative tests, and four devices were tested, namely, the Brown-Duvel moisture tester, the German D-K apparatus, the Berry Dielectrometer, and the Heppenstall moisture meter. The Limbrick and Burton-Pitt devices were not available for study.

Tests with the German D-K (Schnellwasserbestimmer)

The first series of comparative tests was made with the German D-K apparatus (Berliner and Rüter, 1929). This apparatus operates on the dielectric, or capacity principle. The apparatus is first set up in balance with a standard condenser, which is built within the apparatus, by the use of certain designated dials and

switches. A metal condenser of identical electrical capacity is then filled with the grain sample the moisture content of which is to be tested, and this condenser is introduced into the circuit by means of a small bridge. With the introduction of the wheat into the circuit, the capacity of the condenser is altered depending upon the amount of grain as well as its moisture content. With this instrument the change in condenser capacity is not measured in the conventional electric units, as capacity change is expressed in so many units of dial reading. By dividing the dial reading by the weight of the mass of the grain taken for test and multiplying by 100, a unit is established which when plotted against the actual moisture content, as determined by any specified method, makes possible the plotting of a curve from which it is claimed moisture results can be read direct.

The D-K apparatus when received in this country was supplied with a conversion curve which could not be interpreted for 130° C. air-oven performance, so that it was first necessary to construct a conversion curve. Experiments were first made with hard red winter wheat. Ten lots of this class of wheat, five representing the sub-class dark hard winter, and five the sub-class hard winter, were made moist with varying quantities of water and stored away in an ice box to assure soundness until complete penetration of moisture was accomplished. When penetration was complete (72 hrs.) the samples were brought to room temperature (80° F.) and aliquot portions taken for moisture determinations by the 130° C. air-oven method. Wheat with a moisture content presumed to be in excess of 13% was not ground directly but first air-dried (with loss noted) and the residual moisture determined by the 130° C. air-oven method. Actual moisture was determined by noting the combined air-oven losses.

"Volume-weight-dial-reading-factor-values" were then plotted against 130° C. air-oven moisture test results and a series of more or less closely lying curves resulted. These were composited into a master or standard hard red winter wheat curve such as is shown in Figure 1.

The next step, of course, was to determine whether the curve illustrated in Fig. 1 would work. For this purpose a number of market-run hard red winter wheat samples were tested simultaneously by the 130° C. air-oven method and the D-K apparatus, with the results illustrated in Table I, Section A. Using the 130° C. air-oven method as the standard, the average error was 0.67%. The maximum error was 1.94%, and the minimum error was 0.03%.

Only 27% of the tests using the D-K apparatus were within 0.25% of the air-oven method. Previous experiences in other lines of work suggested the thought that perhaps the making of a standard conversion curve from samples which had been made moist by means of adding moisture to a sample was not the proper approach, so that the problem was attacked, in so far as material was avail-

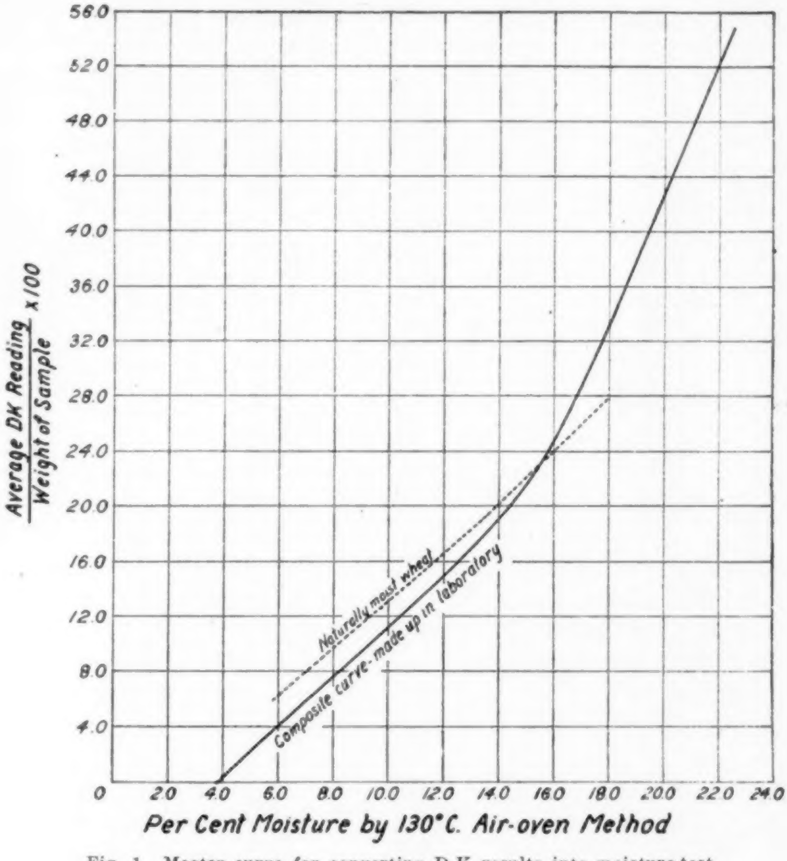

Fig. 1. Master curve for converting D-K results into moisture test results equivalent to those obtained by the 130° C. air-oven method.

able, by selecting wheats that contained a natural but variable moisture content. Unfortunately, wheat of a sufficient variation in moisture content was not available to draw a curve of the length of the first one, but nevertheless it was of sufficient length, (Fig. I) to indicate rather clearly that the making of a conversion curve by the addition of moisture to dry wheat was not the proper thing to do.

TABLE I

COMPARISON OF MOISTURE TEST RESULTS

German D-K Apparatus vs. 130° C. Air-Oven Method

Hard Red Winter Wheats — Crops 1929 and 1930

Sample No.	Section A — Correlated with Curve Prepared by Wetting Samples in Laboratory			Section B — Correlated with Curve Prepared from Samples Naturally Moist Wheat		
	Moisture by 130° C.	Moisture as read from curve	Difference ±	Moisture by 130° C.	Moisture as read from curve	Difference ±
	%	%		%	%	
1	9.89	10.05	.16	9.89	8.97	− .92
2	9.76	10.90	1.14	9.76	9.88	.12
3	9.98	10.98	1.00	9.98	9.98	.00
4	9.38	10.50	1.12	9.38	9.45	.07
5	9.66	10.88	1.22	9.66	9.85	.19
6	9.91	11.50	1.59	9.91	10.50	.59
7	10.43	12.00	1.57	10.43	11.08	.65
8	10.82	12.30	1.48	10.82	11.40	.58
9	10.83	12.15	1.32	10.83	11.25	.42
10	10.18	12.12	1.94	10.18	11.20	1.02
11	10.62	10.65	.03	10.62	9.62	− 1.00
12	10.03	10.88	.85	10.03	9.85	− .18
13	10.00	11.45	1.45	10.00	10.47	.47
14	10.47	10.75	.28	10.47	9.72	− .75
15	10.34	11.20	.86	10.34	10.20	− .14
16	10.78	10.98	.20	10.78	9.98	− .80
17	10.20	10.75	.55	10.20	9.72	− .48
18	10.80	10.95	.15	10.80	9.95	− .85
19	10.85	10.90	.05	10.85	9.85	− 1.00
20	10.40	10.60	.20	10.40	9.50	− .90
21	10.86	11.22	.36	10.86	10.22	− .64
22	10.88	11.30	.42	10.88	10.30	− .58
23	10.80	11.32	.52	10.80	10.32	− .48
24	10.30	11.50	1.20	10.30	10.50	.20
25	11.42	12.15	.73	11.42	11.25	− .17
26	11.80	12.72	.92	11.80	11.90	.10
27	11.03	12.50	1.47	11.03	11.65	.62
28	11.08	12.52	1.44	11.08	11.67	.59
29	11.52	12.83	1.31	11.52	12.03	.51
30	11.85	13.55	1.70	11.85	12.90	1.05
31	11.04	12.55	1.51	11.04	11.73	.69
32	11.22	12.15	.93	11.22	11.25	.03
33	11.35	12.40	1.05	11.35	11.53	.18
34	11.40	13.20	1.80	11.40	12.47	1.07
35	12.76	13.50	.74	12.76	12.85	.09
36	12.08	13.55	1.47	12.08	12.92	.84
37	12.19	12.60	.41	12.19	11.78	− .41
38	12.00	12.62	.62	12.00	11.80	− .20
39	12.10	12.87	.77	12.10	12.08	− .02
40	12.90	12.92	.02	12.90	12.15	− .75
41	12.01	12.87	.86	12.01	12.08	.07
42	12.74	13.58	.84	12.74	12.95	.21
43	12.54	13.15	.61	12.54	12.40	− .14
44	13.47	13.65	.18	13.47	13.05	− .42
45	13.74	14.60	.86	13.74	14.30	.56
46	13.73	13.75	.02	13.73	13.20	− .53
47	13.73	13.50	− .23	13.73	12.87	− .86
48	13.47	13.85	.38	13.47	13.30	− .17
49	13.84	14.88	1.04	13.84	14.65	.81

TABLE I—(Continued)

Sample No.	Section A: Correlated with Curve Prepared by Wetting Samples in Laboratory			Section B: Correlated with Curve Prepared from Samples Naturally Moist Wheat		
	Moisture by 130° C.	Moisture as read from curve	Difference ±	Moisture by 130° C.	Moisture as read from curve	Difference ±
	%	%		%	%	
50	13.86	14.28	.42	13.86	13.85	− .01
51	13.06	14.45	1.39	13.06	14.12	1.06
52	14.58	15.10	.52	14.58	14.95	.37
53	14.51	14.93	.42	14.51	14.70	.19
54	14.96	15.58	.62	14.96	15.72	.76
55	14.19	14.42	.23	14.19	14.08	− .11
56	14.66	15.10	.44	14.66	14.95	.29
57	14.18	14.40	.22	14.18	14.03	− .15
58	14.58	14.80	.22	14.58	14.55	− .03
59	14.60	14.10	− .50	14.60	13.62	− .98
60	14.60	14.48	− .12	14.60	14.15	− .45
61	14.72	14.25	− .47	14.72	13.85	− .87
62	14.05	13.98	− .07	14.05	12.48	− .57
63	14.32	14.45	.13	14.32	14.10	− .22
64	15.01	15.02	.01	15.01	14.88	− .13
65	15.33	15.40	.07	15.33	15.40	.07
66	15.98	15.72	− .26	15.98	15.92	− .06
67	15.49	15.58	.09	15.49	15.70	.21
68	15.02	15.20	.18	15.02	15.10	.08
69	15.40	15.05	− .35	15.40	14.90	− .50
70	15.95	15.60	− .35	15.95	15.75	− .20
71	15.62	15.72	.10	15.62	15.92	.30
72	15.26	15.57	.31	15.26	15.68	.42
73	15.02	14.82	− .20	15.02	14.58	− .44

Although the curve lay in the same plane, it was of neither the same shape nor slope, and as a result produced a different set of moisture test results, as will be seen by reading Table I, section B; results that are much nearer the recognized moisture values. Nevertheless, the moisture test results were too variable for general laboratory use. The average error of testing was 0.45%, with a maximum error of 1.07%, and a minimum error of .0%. With this method of standardization, 40% of the samples were within 0.25% of 130° C. oven values, a somewhat better situation, but yet far from satisfactory.

These results are somewhat at variance with those obtained at the Dominion Grain Research Laboratory, in Canada, where it is believed they find a much higher correlation between the 130° C. air-oven test and the D-K performance. It is believed that these differences may be explained in part by the type of wheat grown in Canada. Predominantly of the Marquis variety, their wheat is more uniform in shape and size than our hard winter wheats, and the mass effect, so important in the D-K determination, may not be near so great as was experienced in our investigations with the

TABLE II

Comparison of Moisture Test Results

German D-K Apparatus vs. 130° C. Air-Oven Method

Soft Red Winter Wheats — Crops 1929 and 1930

Sample No.	Section A — Correlated with Curve Prepared by Wetting Samples in Laboratory			Section B — Correlated with Curve Prepared from Samples Naturally Moist Wheat		
	Moisture by 130° C.	Moisture as read from curve	Difference ±	Moisture by 130° C.	Moisture as read from curve	Difference ±
	%	%		%	%	
74	9.80	9.75	−.05	9.80	9.48	−.32
75	9.78	10.20	.42	9.78	9.90	.12
76	9.79	10.18	.39	9.79	9.88	.09
77	9.91	9.91	.00	9.91	9.65	−.26
78	9.34	10.15	.81	9.34	9.85	.51
79	9.92	10.15	.23	9.92	9.85	−.07
80	10.99	11.58	.59	10.99	11.40	.41
81	10.44	10.82	.38	10.44	10.60	.16
82	10.77	11.00	.23	10.77	10.75	−.02
83	10.43	10.20	−.23	10.43	9.95	−.48
84	10.67	10.35	−.32	10.67	10.12	−.55
85	10.70	11.00	.30	10.70	10.75	.05
86	10.22	10.35	.13	10.22	10.08	−.14
87	10.88	11.05	.17	10.88	10.78	−.10
88	10.62	10.90	.28	10.62	10.65	.03
89	10.41	10.75	.34	10.41	10.50	.09
90	10.94	10.92	−.02	10.94	10.70	−.24
91	10.90	11.25	.35	10.90	11.05	.15
92	10.56	10.90	.34	10.56	10.66	.10
93	10.10	10.48	.38	10.10	10.22	.12
94	11.28	11.65	.37	11.28	11.42	.14
95	11.11	11.37	.26	11.11	11.15	.04
96	11.08	11.70	.62	11.08	11.50	.42
97	11.29	11.12	−.17	11.29	10.90	−.39
98	11.63	12.32	.69	11.63	12.20	.57
99	11.74	12.58	.84	11.74	12.48	.74
100	11.61	12.15	.54	11.61	11.95	.34
101	11.20	11.52	.32	11.20	11.30	.10
102	11.70	11.95	.25	11.70	11.78	.08
103	11.56	11.38	−.18	11.56	11.18	−.38
104	11.92	11.78	−.14	11.92	11.57	−.35
105	11.26	11.40	.14	11.26	11.18	−.08
106	11.00	11.37	.37	11.00	11.18	.18
107	11.32	11.48	.16	11.32	11.27	−.05
108	11.22	11.38	.16	11.22	11.18	−.04
109	11.52	11.67	.15	11.52	11.45	−.07
110	11.28	11.40	.12	11.28	11.18	−.10
111	12.05	12.62	.57	12.05	12.90	.85
112	12.72	12.60	−.12	12.72	12.90	.18
113	12.94	12.98	.04	12.94	12.92	−.02
114	12.41	12.40	−.01	12.41	12.28	−.13
115	12.62	12.50	−.12	12.62	12.38	−.24
116	13.80	14.20	.40	13.80	14.27	.47
117	13.98	14.18	.20	13.98	14.20	.22
118	13.96	14.18	.22	13.96	14.20	.24
119	13.77	12.55	−1.22	13.77	12.45	−1.32
120	13.98	14.28	.30	13.98	14.38	.40
121	13.26	13.55	.29	13.26	13.55	.29

TABLE II—(Continued)

Sample No.	Section A			Section B		
	Correlated with Curve Prepared by Wetting Samples in Laboratory			Correlated with Curve Prepared from Samples Naturally Moist Wheat		
	Moisture by 130° C.	Moisture as read from curve	Difference ±	Moisture by 130° C.	Moisture as read from curve	Difference ±
	%	%		%	%	
122	13.78	13.55	−.23	13.78	13.55	−.23
123	13.40	13.25	−.15	13.40	13.22	−.18
124	13.24	12.92	−.32	13.24	12.85	−.39
125	13.48	13.12	−.36	13.48	13.05	−.43
126	13.54	13.62	.08	13.54	13.62	.08
127	13.72	13.77	.05	13.72	13.80	.08
128	13.68	13.48	−.20	13.68	13.48	−.20
129	13.56	13.60	.04	13.56	13.60	.04
130	14.56	14.58	.02	14.56	14.72	.16
131	14.80	15.25	.45	14.80	15.50	.70
132	14.08	13.48	−.60	14.08	13.48	−.60
133	14.04	14.12	.08	14.04	14.18	.14
134	14.45	14.68	.23	14.45	14.82	.37
135	14.58	14.30	−.28	14.58	14.40	−.18
136	14.80	15.18	.38	14.80	15.32	.52
137	14.68	14.18	−.50	14.68	14.25	−.43
138	14.04	14.20	.16	14.04	14.25	.21
139	14.88	14.85	−.03	14.88	15.02	.14
140	14.12	13.88	−.24	14.12	13.92	−.20
141	14.69	14.38	−.31	14.69	14.48	−.21
142	14.18	14.10	−.08	14.18	14.15	−.03
143	15.95	15.85	−.10	15.95	16.28	.33
144	15.04	14.48	−.56	15.04	14.58	−.46
145	15.15	14.82	−.33	15.15	15.00	−.15

hard red winter wheats grown in the Southwestern part of the United States. This statement is substantiated in part from the data given in Table II, which accumulated from a series of tests made on the soft red winter class of wheats which are more uniform in shape and size than the hard red winter wheats tested. In this series of tests the average deviation from the 130° C. air-oven tests was 0.26%, with a maximum deviation of 0.85% and a minimum deviation of 0.02%. With the soft red winter wheats 62.5% of the tests by the D-K apparatus were satisfactory; 40% were satisfactory with the hard red winter wheats. However, it is believed that any device that does not work equally well on all wheats, regardless of class or variety, is faulty, and for that reason no further tests were made with it.

It is also claimed that the D-K instrument can be used not only for the determination of moisture in flour, but also for tempering purposes. We have not been able to obtain satisfactory performance in determining moisture in flour or applying the instrument to tempered grain. Our conclusions, thefefore, with regard to the

German D-K apparatus are that this device has value as a scientific instrument for certain kinds of laboratory studies, but that it does not produce sufficiently accurate results, nor can it be operated at sufficient speed to be considered a desirable instrument for the purpose of commercial moisture testing.

Comparative Tests with Dielectrometer

The second type of capacity apparatus tested was the Dielectrometer. This device seems to be going through a process of manufacturing evolution. The model tested about two months ago gives results of the same order as those obtained by the German dielectric apparatus. In fact the electrical hook-up is strikingly similar. When this instrument was first put out it was classed as a direct reading instrument. This is not the case, as much better and closer correlations are obtainable by plotting the "volume-weight-dial-reading-factor" against the actual oven tests, such as was the case with the D-K.

The Dielectrometer also exhibited decided operative difficulties, such as, for instance, the matter of keeping it in balance, wearing out of the batteries, as well as an inability to determine the null-point in an unquestionable manner. The conclusions with regard to this instrument are that it is still in the experimental and investigational stage, and not ready for commercial moisture testing.

General Statements Regarding Dielectric Apparatus

Temperature relations, advice to the contrary, are very significant with the dielectric type of instrument. Some may question if there would be sufficient variability in grain temperature under laboratory conditions to cause much concern. Our investigations during the past year indicate that this is a very important factor. Grain, for instance, taken from the elevator or railroad yards with a temperature of, let us say, 45° F., tested for moisture in a laboratory with the instrument at 75° F., or higher, does not give the same results when the grain temperature is 55°, or 65°, or 95° F. To smooth out the difference due to temperature effects, we endeavored to use the temperature coefficient of the dielectric constant of water, and used a correction factor of 0.25% for each change in temperature of 5° F., but this did not prove successful. There was also strong indication that the temperature correction factor was not a linear one, being different for wheats of varying moisture contents.

Another drawback of the apparatus built on the dielectric principle seems to be that a series of conversion charts or tables would have to be made to take care of grain in various stages of purity. For example, conversion curves would have to be made for wheat containing dockage, for dockage-free wheat, and for wheat that has been cleaned and scoured, as the mass effect changes with each cleaning operation. Also from our knowledge of the D-K apparatus, each individual instrument would have to be standardized before use, that is, one conversion curve or table could not be used for a group of instruments.

The general conclusions relative to rapid moisture testers operated on the dielectric principle, therefore, are that they are still in the early experimental stage and it will be some time before they can be seriously considered as applicable to the determination of moisture in all classes, conditions, and kinds of grain.

Comparison of Moisture Test Results by the Brown-Duvel Moisture Tester and the 130° C. Air-Oven Method

The Brown-Duvel moisture tester (Coleman and Boerner, 1926) is recognized as the official apparatus for testing the moisture content of cereal grains when graded under the authority of the United States Grain Standards Act. It was first made known to the trade as early as 1902, in Circular 72 of the United States Department of Agriculture, Bureau of Plant Industry. At this early period, the vacuum-oven method was not in general use, and as a result the standard of moisture testing was by the water-oven method, and the Brown-Duvel test was set-up with the water-oven method as the standard method of reference. As the Brown-Duvel method came into general use it was found to be subject to a number of errors, some due to mechanical defects, others due to the personal equation of the operator.

As a result, a thorough investigation of the sources of error incident to the making of this test was made in 1926. The findings and recommendations in this respect were reported in United States Department of Agriculture Bulletin No. 1375 entitled "The Brown-Duvel Moisture Tester and How to Operate It." The recommendations for making the test as laid down in Bulletin 1375 were quite apart from the original recommendations laid down in Circular 72, and has resulted in eliminating many of the sources of error, common when the tester was operated as described in Circular 72. It is believed that the rank and file of cereal chemists are not fully familiar with the details of the investigations

cited in United States Department of Agriculture Bulletin No. 1375, otherwise there would not be such a widespread intolerance against the method, particularly as regards its accuracy, if operated under the strict specifications of the method.

Tests comparing the accuracy of the Brown-Duvel moisture tester with the 130° C. air-oven method were carried on with the five commercial classes of wheat, namely, the hard red winters, the hard red springs, the durum, the soft red winter, and the common white wheats. In Table III is listed the total number of samples tested, as well as the frequency with which samples in a given moisture range were tested.

Comparative tests made with 147 samples of hard red winter wheat show that on the average the Brown-Duvel tests deviated from the 130° C. air-oven test by 0.26%. The maximum deviation was 0.9%. Sixty-five per cent (65%) of the tests deviated by 0.2% or less; 13% by 0.3%; 16.3% by 0.4%; and 16% by 0.5% or greater.

The results of the comparative tests made with the 101 samples of hard red spring wheat were similar. The average deviation from oven tests was 0.22%. The maximum deviation was 0.6%. Sixty-one and four-tenths per cent (61.4%) deviated from the 130° C. air-oven tests by 0.2% or less; 17.8% by 0.3%; and 9% by 0.4%; with 12% showing a deviation of 0.5%, or greater.

Tests were made on 35 samples of durum wheat. The correlation was greater. The average deviation from the oven test was 0.14%. Eighty-five per cent (85%) of the Brown-Duvel tests were within 0.2% or less; 8.5% deviated 0.3%, with only 6% varying by as much as 0.5%.

One hundred and twenty-four (124) comparative tests were made with the soft red winter wheats. The average deviation from the 130° C. air-oven method was 0.42%. The maximum deviation was 1.3%. Only 34.1% of the tests were within 0.2% or less of the air-oven results. Also, as much as 41.9% of the tests deviated from the 130° C. air-oven values by 0.5%, or greater.

Comparative tests were made with the 58 samples of white wheat, i.e., both hard and soft white. The maximum deviation was 1.1%. The average deviation from oven tests was 0.51%. Twenty-two and five-tenths per cent (22.5%) of the tests were within 0.2% or less of the oven values; 12% of the tests deviated by 0.3%; 19.0% deviated by 0.4% of the oven tests; while 46.5% deviated by 0.5%, or more, from the oven tests.

A summary of the results comparing the Brown-Duvel moisture tests and the 130° C. air-oven test is shown in Table IV.

TABLE III

FREQUENCY DISTRIBUTION OF WHEAT SAMPLES STUDIED

Class of Wheat	Per Cent Moisture Content of Samples by the 130° C. Air-oven Method										Total Number of Samples Tested
	8.0 to 8.9	9.0 to 9.9	10.0 to 10.9	11.0 to 11.9	12.0 to 12.9	13.0 to 13.9	14.0 to 14.9	15.0 to 15.9	16.0 to 16.9	17.0 to 17.9	
Hard red winter	4	7	25	26	39	20	9	14	2	1	147
Soft red winter	0	10	16	22	15	31	18	6	4	2	124
Hard red spring	1	3	11	37	22	20	5	1	1	0	101
Durum	0	2	2	7	14	5	4	0	0	0	35
White	0	5	14	19	13	2	2	2	1	0	58

TABLE IV

COMPARISON OF MOISTURE TEST RESULTS, BROWN-DUVEL vs. 130° C. AIR-OVEN METHOD, ALL CLASSES WHEAT CROPS 1929 AND 1930

Number Samples Tested	Class of Wheat	Per Cent of Tests Deviating from 130° C. Air-oven Test in Increments of One-tenth Per Cent									
		.1 or less	.2	.3	.4	.5	.6	.7	.8	.9	1.0 and over
147	Hard red winter	34.7	20.4	12.9	16.3	10.2	1.4	2.7	1.4		
124	Soft red winter	20.2	13.9	10.5	13.7	8.9	12.9	9.7	3.2	2.4	4.8
101	Hard red spring	43.6	17.8	17.8	8.9	6.9	5.0				
35	Durum	57.0	28.5	8.5	3.0	3.0					
58	White	15.5	7.0	12.0	19.0	3.4	12.0	7.0	10.4	1.7	12.0

It is evident from the previous discussion as well as the data given in Table IV, that the closest correlations with oven tests were obtained when using the Brown-Duvel method on the hard classes of wheat. The greatest variability was experienced with the soft wheats.

Tests Made with the Heppenstall Moisture Meter

The estimation of moisture by conductivity measurements depends upon the variation in electrical resistance with changing moisture content of the grain. The measurement of resistance is based on Ohm's Law, which states that the strength of a current equals the electromotive force divided by the resistance.

It was stated earlier that the Heppenstall moisture meter operates on the conductivity principle. In the minds of some, conductivity apparatus, in general, is doomed to failure on purely theoretical grounds, for it is reasoned that inasmuch as conductivity is a direct function of the mineral matter of the grain, and that the mineral matter is exceedingly variable from wheat to wheat, or cereal to cereal, no consistent or significant readings could be made.

The variation in mineral content is admitted without argument. However, it is an observed fact that electrical resistance decreases rapidly as moisture content increases. The electrical resistance of wheat, for example, with 13% of moisture, is approximately seven times as great as that of wheat with 14% of moisture and 50 times as great as wheat containing 15% of moisture, and so on up the scale.

Attempts to use conductivity measurements to measure moisture content are interesting historically. Zeleny (1909) of the Department of Physics of the University of Minnesota, developed an electrical method for determining the moisture content of corn. This was apparently of only academic interest, as it appears nothing of commercial importance developed from his work in the matter of commercial moisture testing apparatus. One of the most serious difficulties attendant upon his early apparatus was the testing of bulk grain, and the effect of polarization while measuring the moisture content of grain of high moisture content.

At about the same time that Zeleny was making his experiments, Briggs (1908) of the United States Department of Agriculture, reported investigations using the same conductivity principle. Instead of the prong electrode, suggested by Zeleny, Briggs employed two rod-type brass electrodes of definite size and shape.

These were inserted into a jar of grain to a certain depth and at a specified distance apart in order to arrive at a definite grain pressure and the electrical resistance of the system determined. While Briggs' equipments were a decided improvement over Zeleny's, he also failed of his objective due to his inability to adequately control grain pressure requirements, and also because his method could not take care of polarization effects without reference to a special type of equipment. Due to inefficient insulation, current leakage was also extensive.

In the Heppenstall device these three sources of error have been almost entirely eliminated. The electrodes, instead of being prong, or rod-like in shape, are corrugated rolls, effectively insulated from the other parts of the electrode mechanism by means of bakelite, so that current leakage is practically eliminated.

The corrugated roll makes for a seizing of the kernel, holding it in place for the duration of the test. In the hand-operated model, one of the rolls is on an eccentric bearing, and can be moved forward and backward, by means of a lever, so that the spacing between the rolls can be accurately adjusted to very fine limits. Permanency of adjustment is assured by means of a set-screw device. In the motor-driven model, the roll-spacing is changed by means of accurately calibrated shims.

Roll spacing is important as it controls the pressure applied to the grain as it passes through the rolls, making this factor reasonably uniform from sample to sample. Roll spacing is further important in that it varies somewhat for different commodities. For example, corn takes a roll spacing 0.110 in., while rice passes through more properly at 0.025 in.

Polarization has been practically eliminated in the Hppenstall device due to the fact that as the rolls are in motion during the test, polarization effects do not have an opportunity to materialize, at least not sufficiently so as to be of operative importance.

Finally, inasmuch as the test is made on each individual kernel as it passes through the rolls, the final result of the test is, in effect, the average of many moisture tests on the same lot of grain.

The geared roll feature of the Heppenstall device as well as the ability to change and maintain the pressure applied to the grain are most important, and therein lies much of the effectiveness of the apparatus.

The measurement of resistance by the Heppenstall device, as just pointed out, is based on Ohm's law $I = E/R$. In the Heppenstall device the circuit is so designed that corrections for variations in

"E" may be made by altering the resistance in the ammeter circuit. Under these conditions the strength of the current flowing is inversely proportional to the resistance and the ammeter reading may be interpreted as a measure of the moisture content of the sample, providing the exact moisture content by any given laboratory method is known. One can readily understand then, that if the exact moisture content and electrical resistance readings of a series of samples of varying moisture content are available, they would readily lend themselves to plotting or charting, and it would be possible from such curves to convert instrument readings directly into moisture percentages.

The operation of the instrument is simplicity itself. The grain for testing is placed in the hopper of the electrode device and is allowed to pass through the rolls by turning the rolls at a definite speed—between 36-37 turns per minute. At the same time the resistance to the passage of the electric current is noted by means of a resistance measuring box. Conversion from instrument readings to moisture readings is direct. The entire operation consumes less than a minute of time.

Electrical conductivity measurements are influenced by changes in temperature as well as any other electrical measurement. In fact, with wheat the rapidity with which electrical resistance decreases as temperature increases is quite remarkable. The electrical resistance at 40° F., is 18 times that at 75° F., so that before a final figure for moisture content can be given, corrections for temperature influences are necessary.

Fortunately, for most cereals, this appears to be a straight linear correction of 0.04% per degree change in temperature. So while the test is being made a thermometer is placed in the sample sack, or can, and the grain temperature noted.

To provide uniformity of expression of results between different operators, a certain definite point has to be selected to which all values must be corrected. Amongst most laboratory operatives this point is usually 25° C. or 77° F. Thus in making a final audit of the moisture percentage, for every degree in grain temperature below 77° F., 0.04% is added to the observed moisture reading, while for every degree above 77° F. a deduction of 0.04% is made. This procedure may seem rather clumsy at first, but after a few trials the correction factor procedure becomes routine.

The tests made with the Heppenstall moisture meter were upon the same series of samples that were tested on the Brown-Duvel apparatus. The results of the comparative tests are given

in Table V. They show that with the hard red winter wheats the average deviation from the air-oven test results was 0.17%. Seventy-eight and two-tenths per cent (78.2%) of the tests deviated by 0.2% or less; 12.9% deviated by 0.3%; 4.1% deviated by 0.4%, while 4.6% deviated by 0.5% or more.

With the hard red spring wheats the average deviation from the 130° C. air-oven tests was 0.13%. Eighty-five and two-terths per cent (85.2%) of the tests were within 0.2% or less of the oven test, 10.9% were within 0.3%, and 4% were within 0.4%.

The average deviation from the 130° C. oven test experienced with the durum wheats was 0.12%. Eighty-five and one-tenth per cent (85.1%) of the tests were within 0.2% or less, of the oven results; 11.5% were within 0.3%, while 3.2% were within 0.4%.

The soft red winter and white wheats gave the most operative difficulty. This difficulty in the instance of the soft red winter wheats was due largely to garlic and chess. With the soft red winter wheats the average deviation was 0.19%. The maximum deviation from the oven test results was 0.7%. Seventy-five and eight-tenths per cent (75.8%) of the samples deviated by 0.2% or less from air-oven tests; 11.3% of the samples deviated by 0.3%; 5.6% by 0.4%; and 7.3% by 0.5% or over.

With the white wheats the average deviation from the air-oven tests was found to be 0.24%. Sixty-six per cent (66.0%) of the tests deviated by 0.2% or less; 8.7% deviated by 0.3%; 12.0% deviated by 0.4%, and 13.3% deviated by 0.5% or over. The average deviation from 130° C. tests was 0.24%. The maximum deviation was 0.8%.

A summary of the data comparing the 130° C. air-oven tests with those obtained by the Heppenstall moisture meter is shown in Table V.

TABLE V

Comparison of Moisture Test Results, Heppenstall vs. 130° C. Air-Oven Method, All Classes of Wheat, Crops 1929 and 1930

Number of Samples	Class of Wheat	Per Cent of Tests Deviating from 130° C. Air-oven Test in Increments of One-tenth Per Cent							
		0.1 or less	0.2	0.3	0.4	0.5	0.6	0.7	0.8
147	Hard red winter	53.1	25.1	13.0	4.1	4.6			
101	Hard red spring	60.4	24.8	10.9	4.0				
35	Durum	71.1	14.3	11.5	3.1				
124	Soft red winter	53.2	22.6	11.3	5.6	3.2	1.6	2.5	
58	White	40.0	26.0	8.7	12.0	5.0	3.3	3.3	1.7

It is quite evident from a comparison of the data given in Table V with that given in Table IV, wherein the moisture test

results by the Brown-Duvel moisture tester are recorded, that on the basis of average deviations from the standard test, as well as the distribution of accuracy within the various series of tests that the Heppenstall moisture meter will give just as accurate results as the Brown-Duvel moisture tester under normal laboratory conditions. This is truly a remarkable performance from an instrument that is only one year old, and in which a moisture test can be made in approximately one minute. Furthermore, all the data discussed to date were obtained on hand operated machines. Since these data were accumulated, the electrode part has been motorized and as a result some of the minor sources of error inherent in the first model, have been eliminated.

Other Features of the Heppenstall Moisture Meter

One of the most outstanding considerations with respect to laboratory equipment should be its ability to be easily standardized, so that uniformity—in apparatus and technique—will be the effect.

The Heppenstall device lends itself very easily to this requirement. Evidence to this effect is shown in Table VI, wherein ten samples of variable moisture content were tested for moisture on five individual Hepenstall moisture meters, the conversions all being made from the same standard chart. The average meter difference was 0.1%.

Further proof that this device is of decided influence in reducing moisture testing errors is to be seen from that data given in Table VII, wherein data are recorded of collaborative tests made on six samples of wheat varying in moisture from 10.5% to 15.3% at five different points on five different Heppenstall moisture meters, by five different individuals. For comparative purposes, the same samples were also tested by the Brown-Duvel method. By use of the Heppenstall device, the maximum error of test on these six samples was 0.25%, while the error by the Brown-Duvel method was 0.60%.

Again, an instrument to be successful must be an all-purpose instrument. Most of you are naturally "wheat-minded" and are only passively interested in the application of this instrument to the determination of moisture in other cereals. For those of you who are, it will be interesting to know that this Heppenstall device is now operating with the same degree of accuracy with respect to determining the moisture content of corn and rye, and

that extensive research is being carried on perfecting the technique for oats, barley, and the grain sorghums. In addition, although no attempts to go into the matter thoroughly have been

TABLE VI

ACCURACY OF HEPPENSTALL MOISTURE METERS

Meter No. 1	Meter No. 2	Meter No. 3	Meter No. 4	Meter No. 5	Meter Difference
		Per Cent Moisture			
13.7	13.7	13.7	13.7	13.7	.0
14.2	14.3	14.3	14.4	14.4	.2
14.2	14.2	14.3	14.3	14.2	.1
13.5	13.6	13.6	13.6	13.6	.1
14.5	14.5	14.5	14.5	14.5	.0
10.7	10.6	10.7	10.7	10.7	.1
10.2	10.1	10.1	10.1	10.1	.1
9.9	10.0	10.0	10.0	10.1	.2
10.3	10.4	10.4	10.4	10.4	.1
9.5	9.5	9.6	9.5	9.6	.1
Average meter difference					.1

TABLE VII

COMPARATIVE MOISTURE TEST RESULTS HEPPENSTALL MOISTURE METER AND BROWN-DUVEL TESTER

Location of Tester						
Washington	Baltimore	St. Louis	Chicago	Kansas City	Range in Results Per cent	Average Difference Per cent
Per Cent Moisture by Tag-Heppenstall Device						
10.5	10.6	10.4	10.2	10.6	.4	
11.2	11.2	11.2	11.1	11.3	.2	
11.8	11.8	11.7	11.6	11.8	.2	
13.4	13.4	13.4	13.3	13.5	.2	
14.7	14.7	14.6	14.6	14.6	.1	
15.3	15.4	15.2	15.0	15.3	.4	0.25
Per Cent Moisture by Brown-Duvel Tester						
10.0	10.4	9.6	10.1	10.4	.8	
11.2	11.1	10.7	10.8	11.0	.4	
11.8	11.6	11.0	11.8	11.8	.8	
13.2	13.2	13.2	13.3	13.6	.4	
14.7	14.4	14.4	14.4	15.0	.6	
15.2	15.0	14.8	15.1	15.4	.6	0.60

made to date, it is evident from preliminary tests that the moisture content of even such fine materials as grass seeds, and such large materials as lima beans and peanuts, can be determined.

Limitations of the Heppenstall Moisture Meter

The impression must not be created that the research with regard to the Heppenstall moisture meter is entirely finished,

that it will work under any and all conditions, and that we are satisfied with its performance. As is usual with all research work on new devices and methods, there are a number of loose ends which need tying in.

The application of the tester to the tempering process, for instance, has been attempted, and at the present time offers a stubborn resistance to solution, but it is believed that a method will be eventually forthcoming. The same difficulty incident to the tempering problem is also at hand, when one comes to the determination of moisture in freshly washed grain, and on tests for mixtures of freshly washed grain and dry grain.

Investigations relating to the accurate determination of moisture in out-of-condition grain are not complete. Wheat in an incipient state of spoilage does not appear to influence the moisture test results. With the most outstanding types of heat damage, musty, and sour grain, we have noted a deviation of 0.5% from oven test results.

Treated grain, i.e., sulphured, limed, etc., will probably offer some operative difficulties.

The instrument will not, as now constructed, determine the moisture content of low moisture content wheat, of extremely low temperature. That is, at a grain temperature of 32° F. or below, it becomes increasingly difficult to determine the moisture content of grain with a moisture range of 8-11% because of the high resistance piled up in grain of such low temperatures.

Grain that has been covered with snow, or fine ice, in addition to the temperature factor, offers resistance to accurate test because of the free moisture present on the surface of the grain.

Taking into consideration the broad aspect of the situation, however, rather than the special problems, the device does remarkably well, and certainly merits the trial of all those concerned with the merchandizing and processing of grain.

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MINUTES OF THE SEVENTEENTH ANNUAL CONVENTION OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

M. D. Mize, Secretary-Treasurer

Brown Hotel, Louisville, Ky.

May 18-21, 1931

Monday, May 18

Convention called to order at 10:00 a. m. by President C. G. Harrel.

Invocation by the Reverend B. G. Hodge.

Judge Huston Quin of Louisville, after being introduced by L. D. Whiting, welcomed the Association's members assembled to Louisville and Kentucky, assuring them that true "Southern hospitality" would be extended to them during the week.

Dr. A. W. Homberger, Director, Department of Chemistry, University of Louisville, described the chemical industries located in and near Louisville, mentioning those that were visited on the Industrial Tour, Tuesday afternoon.

Mr. F. A. Madge of Nobelsville, Ind., President of the Operative Millers' Association, extended the following message of greeting in person:

"When your president, Mr. Harrel, graciously extended an invitation to the Association of Operative Millers to be represented at this Convention, our Secretary, Mr. Hugo Ross, requested me to accept the honor.

"As President of the Association of Operative Millers, I first want to say that it would be impossible for me to over-emphasize the great pleasure it gives me to bring you greetings and good wishes from our Association. May this, your Seventeenth Annual Convention, bring to you greater knowledge and understanding of your chosen profession than you have ever before enjoyed, and may this be the best convention in your history.

"These yearly gatherings in convention are productive of incalculable benefit to the individual chemist, which is reflected in his work throughout the year, and the bits of knowledge gleaned here and there by virtue of personal contact with your fellowmen in the same field of endeavor, radiates a fund of information obtainable from no other source, and for all these earnest endeavors you are individually and collectively to be most heartily congratulated; especially would I mention the splendid service and co-operation you are rendering the operative miller in his struggle to improve the 'staff of life.' We are pleased to accept this wonderful aid and co-operation and to share with you our knowledge on all questions pertaining to successful flour mill operation. Milling today is much more complicated than it was thirty years ago, at which time chemists were just beginning to take an active interest in flour mill operations, and which caused no end of worry and speculation among the operative millers of that time, who for the most part concluded that the chemist was going to supersede him as mill superin-

tendent. In consequence of this, the chemists were not very well received by the miller, but as time went on the miller began to realize that the chemist was sprouting wings rather than horns, and that after all the chemist was a mighty fine fellow with whom to counsel when in trouble, for it is a fact that the chemist is of a sympathetic nature, and always willing to render his very best service when called upon to do so. This is co-operation of a very high degree, and when such relations prevail between chemist and miller, results in the mill are most satisfactory to the management. Linking the destiny of the chemist and the miller—the science of the former and the art of the latter—the milling industry is destined to take its place in the vanguard of commercial industry.

"Gentlemen, I wish to conclude these remarks by paying the grateful respects of the Association of Operative Millers to The American Association of Cereal Chemists, also my personal respects to a few of the pioneers of Cereal Chemistry, whom it has been my very great pleasure to have known; such men as Prof. L. A. Fitz, Dr. Harry Snyder, Dr. H. A. Barnard and my very good friends, Dr. E. E. Werner, Dr. C. O. Swanson and Dr. C. H. Bailey—all honor to these fine men and their associates for the splendid work they have accomplished. I also wish to congratulate your president, Mr. Harrel, Mr. Whiting and the local committee for their excellent management of this convention, as judging from the program and entertainment features it is due to be an eminent success."

L. R. Olsen, Chairman of the Northwest Section, extended greetings from his section. L. E. Leatherock, Vice-Chairman of the Pioneer Section, spoke in behalf of his section. W. A. Richards of the Niagara Frontier Section, read a message from W. F. Farrel, Chairman of that section. P. E. Minton, Chairman of the Midwest Section, delivered a message of greeting from his section. R. M. Sandstedt, Chairman of the Nebraska Section; Bert D. Ingels, Chairman of the New York Section, and N. T. Cunningham, Chairman of the St. Louis and Central States Section, also delivered messages of greeting and good wishes from their respective sections.

Communications were received and read from the following: Geo. H. Buford, L. H. McLaren, M. F. Dillon, Robert Dewar, H. F. Vaupel, E. D. Soesman, and D. W. Kent-Jones.

In memory of Frank W. Emmons, the members, assembled, stood in silent meditation for three minutes.

The following convention committees were appointed by President Harrel:

Nominating committee: M. A. Gray, Chairman, H. E. Weaver, A. W. Meyer.

Auditing committee: C. E. Mangels, Chairman, Bert D. Ingels, V. E. Fisher.

Resolutions committee: L. H. Bailey, Chairman, C. B. Morison, Fred J. Lumsden.

President Harrel's Personal Convention Committee: Earl C. Paulsel, E. N. Frank, C. H. MacIntosh, E. E. Smith, F. L. Dunlap, G. Moen, R. B. Potts.

L. D. Whiting, Chairman of the Local Arrangements Committee, outlined the entertainment to take place during the Convention.

Mrs. L. Armstrong, in charge of the entertainment for the ladies during the Convention, was introduced.

President Harrel's address was broadcast in Washington, D. C., by C. C. Fifield over the Blue Network of the National Broadcasting Co., and received by radio in the Convention hall.

T. W. Vinson, assistant to the President, Brown Hotel, extended a welcoming greeting from the hotel.

Meeting adjourned at 12:10 p. m.

Meeting called to order at 1:30 p. m. by President Harrel.

An invitation was extended by a representative from Detroit to hold our 1932 Convention in their city.

Meeting was then placed in charge of Bert D. Ingels.

Report of the Committee on Standardization of Laboratory Baking by C. H. Bailey, was read by M. A. Gray.

Report of the Laboratory Baking Fellow by Paul P. Merritt.

The following message of greetings was received from President Herbert Hoover:

"I will be obliged if you will express my cordial greetings to those present at the Seventeenth Annual Convention of the American Association of Cereal Chemists and my appreciation of the value of their work of scientific control and research exercised in the manufacture of wheat products."

Messages were also received from Arthur M. Hyde, Secretary of Agriculture; M. Lee Marshal, president Continental Baking Co.; W. L. Harvey, president International Milling Co.; A. L. Estes; Southwestern Miller, Sosland Bros., Editors; R. L. Nafziger, president Interstate Bakeries Corp.; M. J. Blish; Geo. F. Huber, president Huber Baking Co., and the Eagle Roller Mills.

Paper—"Observations on the Precipitation of Mercury in the Kjeldahl Method" by Claude F. Davis, was read by R. J. Clark.

Paper—"The Modification of the Basic Baking Test for Use with Low Diastatic Flours" by M. C. Markley and C. H. Bailey, was read by R. C. Sherwood.

Paper—"The Utility of Machine Moulding in Experimental Baking" by W. F. Geddes and C. H. Goulden.

Greetings were sent to our members who were unable to attend the Convention by R. J. Clark broadcasting over Station WHAS.

Report of the Committee on Methods of Chemical Analysis by J. T. Flohil, Chairman: "Protein and Moisture Determinations in Wheat with Special Reference to Conditions Governing Preparation of Samples for Analysis."

Sub-report by D. A. Coleman, "Moisture Determination in Wheat, with Special Reference to Quick Methods."

Sub-report by A. W. Meyer, "The Chemical Analysis of Some Important Baking Ingredients."

Sub-report by W. C. Meyer, read by J. T. Flohil, "The Direct Ash Method."

Meeting adjourned at 5:00 p. m.

A joint meeting of the Louisville Section of the American Chemical Society and the American Association of Cereal Chemists, preceded by a dinner at 6:30 was called to order by R. C. Sherwood at 7:30 p. m.

Address—"Relation of Plant Nutrition to Composition of Wheat," by Dr. H. R. Kraybill, Purdue University, Lafayette, Indiana.

Meeting adjourned 9:00 p. m.

Tuesday, May 19

Meeting called to order by President Harrel at 9:00 p. m.

Messages of greeting were read from Thad L. Hoffman; J. H. Lanning; E. L. Von Eschen; Elmer F. Hathaway, Hathaway Bakeries Inc.; Warner B. Bishop; Ralph S. Herman; Howard M. Simmons, Midwest Laboratories; Fred Hildebrand; L. E. Bowman; Joseph Wilshire, president, Standard Brands, Inc.; Peter Pirrie; Model Home Bakery; Adam Pfau; Ralph S. Willard; E. O. Jones, Commander-Larabee Corp.; C. F. Moore; W. G. Coates; Olaf Strand; C. J. Patterson; L. G. Hall; Zion Baking Industry; Gordon Smith; American Miller; Geo. D. Stevens; H. R. Tucker; S. M. Briggs; Guy A. Thomas, Commander-Larabee Corp.; G. M. Walker; Governor Ritchie of Maryland; Governor Harry G. Leslie of Indiana, and Hugo Roos.

L. R. Olsen presented a composite photo of the ten past presidents of the Association: H. E. Weaver, C. J. Patterson, R. W. Mitchell, S. J. Lawellin, M. J. Blish, R. J. Clark, L. R. Olsen, C. E. Mangels, M. A. Gray, and C. G. Harrel to each of the past presidents.

Victor E. Marx, secretary-treasurer American Society of Bakery Engineers, was introduced and spoke a few words of greetings from the Society.

Meeting was then placed in charge of L. D. Whiting, chairman for the morning.

Paper—"The Cake Baking Test as Opposed to Flour Analysis Alone for Determining the Cake Making Value" by R. T. Bohn.

Paper—"Some Factors Influencing the Emulsions Formed by Beating Butter, Sugar, and Eggs" by Emily Grewe.

Paper—"A Study of Methods of Testing Cake Flour" by J. W. Montzheimer was read by H. D. Liggitt.

Paper—"A Practical Doughing Test of Cake Flour" by J. W. Eckhart.

Report of the Committee on Methods of Testing Cake and Biscuit Flour by Mrs. Mary M. Brooke, Chairman.

Sub-report by G. L. Alexander, "Creaming for a Definite Time Compared with Creaming to a Definite Specific Gravity."

Sub-report by L. H. Bailey, "Reports on Methods of Adding Ingredients to Cake Mixtures."

Sub-report by C. B. Kress, "The Relation Between the Percentage of Flour and the Percentage of Sugar in a Cake Testing Formula" was read by Mrs. Brooke.

Sub-report by E. E. Smith, "Viscosity and the Test Cake."

Sub-report by R. A. Barackman, "Score Cards."

Sub-report by J. A. Dunn, "Some Observations on Family Flour."

Meeting adjourned at 12:10 p. m.

Meeting called to order by President Harrel at 7:30 p. m. and placed in charge of L. R. Olsen.

Paper—"New Fumigants for Destroying Insect Pests in Foodstuffs," by R. C. Roark of the United States Department of Agriculture.

Paper—"Two Aspects of the Relationship Between Laboratory Tests and Plant Results," by Washington Platt.

Paper—"The Soft Winter Wheat Improvement Program for Ohio," by E. G. Bayfield.

Paper—"Physical Tests Indicating Quality of Dry Skim Milk for Bread Making," by E. N. Frank.

Meeting adjourned at 9:00 p. m.

Wednesday, May 20

Meeting called to order by President Harrel at 8:00 a. m.

Report of Executive Committee

R. K. Durham, Chairman

In addition to its routine duties of approving bills payable and passing upon applications for membership during the past year, the Executive Committee has voted to grant charter certificates Nos. 8 and 9 to Midwest and New York Sections; has instructed the Secretary-Treasurer to render his annual financial report as of the close of business on the last day of December instead of at convention time as has formerly been the custom; and after careful study has approved the proposed plan to install newly elected officers at the close of convention rather than immediately following election. Such a plan has obvious advantages and does not conflict with our Constitution which states that: "Officers of the Association shall be elected to serve for a term of one year or until their successors are installed." Unless objection is raised at the conclusion of this report, the new schedule for installation of officers will be put into effect at this Convention.

Inasmuch as the number of local sections is increasing, the Executive Committee recommends that your President appoint a committee to conduct a survey of the local section problem and make a report to the next Executive Committee. These recommendations to deal with the possibility of defining the boundaries and minimum membership of local sections. Existing local sections should be given a voice in the preparation of these recommendations.

The following proposed amendment to our Constitution has been duly published and presented to the Executive Committee for consideration: It is proposed that Article 4 be amended by adding Section 8, *Council*.

"Each local section, in good standing, shall elect one councilman at its first regular meeting in the calendar year. These councilmen shall take office on the first day of the annual convention and shall hold at least two meetings during the convention. They shall elect their own chairman at their first meeting and he shall automatically become a member of the Executive

Committee for the ensuing year with the election of officers. The Council shall constitute the representative body and shall make their report and recommendations to the President, Executive Committee, or the convention assembled. The Council shall assume all the duties of the nominating committee."

Further, it is proposed that Article 7, Section (b) be amended by adding the words "And Councilman."

The Executive Committee feels that since the Constitution in its present form is quite adequate, extreme caution should be exercised in its alteration. Furthermore, this amendment, if carried, would make an even number on the Executive Committee which might lead to a tie in its voting, would make the committee larger and more cumbersome and would add little to the present satisfactory scheme of things. For these reasons this committee does not approve of the proposed amendment. Such disapproval does not mean defeat for the amendment, it may yet be brought before the Convention for consideration under the head of new business.

Moved by R. K. Durham that the report be accepted. Seconded, carried.

Moved that the Executive Committee's recommendation that the newly elected officers be installed at the close of the Convention rather than immediately following election. Seconded, carried.

Report of the Committee on Allied Associations

L. R. Olsen, Chairman

A brief report of the activities of this Committee was given by the Chairman.

Report of the Membership Committee

A. D. Wilhoit, Chairman

The following members obtained one or more new members during the year:

C. H. Bailey	M. L. Blish	H. S. Boeddeker	Pearl Brown
T. E. Carl	F. A. Collatz	Robert Dewar	C. N. Frey
Jacob Freilich	H. O. Gilmer	Paul Gottschalk	M. A. Gray
C. G. Harrel	W. L. Heald	B. D. Ingels	L. E. Jackson
H. H. Johnson	Sam Lawellin	Ruth Lorimar	F. J. Lumsden
H. D. Liggitt	A. D. McGuire	W. C. Meyer	A. W. Meyer
J. Micka	M. D. Mize	J. H. Monson	C. B. Morizon
C. T. Newell	F. X. Nodler	C. R. Norman	L. R. Olsen
A. J. Pacini	Earl Paulsel	A. R. Sasse	E. D. Soesman
W. E. Stokes	George Stadler	Betty Sullivan	A. S. Thatcher
E. Rex Uphouse	E. L. Von Eschen	J. D. Vernon	H. G. Walter
A. L. D. Warner	J. W. Whitacre	L. D. Whiting	

Harry D. Liggitt was the high man in the contest with seven new members for the year; although it should be mentioned that C. G. Harrel, who was ineligible in the contest, obtained eight new members. T. E. Carl was second with four new members.

The standing of the various Sections is as follows figured on the basis of the number of points per member; the officers and committee chairmen were not included:

New York Section	.91
Pioneer Section	.477
Northwest Section	.4677
Midwest Section	.406
Nebraska Section	.28
Kansas City Section	.4666
St. Louis & Central States	.382
Niagara Frontier Section	.00
Pacific Northwest Section	.00

Moved by Bert D. Ingels that report be accepted. Second, carried.

In the absence of Julius Hendel, chairman of the Question Committee, C. G. Harrel gave a short report.

Committee on Osborne Medal Award

No report was given by the Committee.

Publicity Committee

L. H. McLaren, Chairman

In the absence of L. H. McLaren, chairman of the Publicity Committee, C. G. Harrel gave a short talk on the work that had been done during the year.

Report of History Committee

R. Wallace Mitchell, Chairman

The work of the Committee during the past year has been confined very much to the problem of organizing the material previously accumulated and in editing the copy.

We are submitting the results of our efforts in a form that is not entirely complete but there are a few details and some data which will require further effort before the Committee would feel justified in being satisfied to approve.

The entire report is assembled in a manner which will permit of adding to and in a limited way of rearranging to suit the ideas of the Executive Committee.

We feel that the President and the Executive Committee should consider the entire effort rather carefully and make such suggestions to this or the future committee as may seem desirable.

The history of the Association has been brought up to the time that this committee was appointed. When the work thus far is approved, then it will be much simpler to compile the record for the last several years.

The Committee would like to suggest that at the proper time, a mimeograph copy be made and distributed to each of the past presidents and past officers so that other items of historical interest may be uncovered. It is very possible that the general conclusion may be that the viewpoint of the Committee has not been just what is most desired. There are a number of factors in connection with the development of an effort such as this, which may be viewed with differing weight by the majority of the members.

We do not wish the History to be considered as approved until it has had the most critical consideration of a number of our most representative members.

R. W. Mitchell moved that the report be accepted. Seconded, carried.

Employment Committee Report

C. B. Morison, Chairman

Letters, Correspondence from May 6, 1930 to May 18, 1931		84
Letters, from May 29, 1925 to May 5, 1930		645
Positions filled		4
Employers requesting assistance		8
Names registered this year from May 6, 1930 to May 18, 1931	20	
Previous names registered	145	
Total		165

Moved and seconded that the report be accepted. Carried.

Report of Auditing Committee

C. E. Mangels, Chairman

The Auditing Committee has examined the records in so far as practicable and found same to be correct.

The Auditing Committee wishes further to commend the present system of making reports on basis of the calendar year.

The Auditing Committee further recommends that the incoming President appoint a committee of members in Omaha, who with Mr. Mize will examine and check the contents in the safety deposit box in Omaha, and report their findings to the President.

C. E. Mangels moved that the report be accepted. Seconded, carried.

Report of the Secretary-Treasurer

M. D. Mize

This report was printed in Cereal Chemistry, **8**: 175-178.

C. E. Mangels moved that the Secretary-Treasurer's report be accepted. Seconded, carried.

Report of the Committee on Methods of Testing Cake and Biscuit Flours

Mary M. Brooke, Chairman

The full report of this Committee is given on pages 252 to 265 inclusive of this issue of Cereal Chemistry.

Moved by Mary M. Brooke that the report be accepted. Seconded, carried.

Report of the Committee on Resolutions

L. H. Bailey, Chairman

Whereas the American Association of Cereal Chemists has been privileged to hold another successful convention and

Whereas the success of this convention has been due largely to the untiring efforts of the officers and committees of this Association

Therefore be it resolved that the thanks of this Association be extended to our President; C. G. Harrel; our Vice-President, R. K. Durham; our Secretary-Treasurer, M. D. Mize; the program committee, Emily Grewe, chairman; and the local arrangements committee, L. D. Whiting, Chairman; also to the Methods committee, J. T. Flohil, Chairman; the committee on testing cake and biscuit flours, Mary M. Brooke, Chairman; and the committee on standardization of laboratory baking, C. H. Bailey, Chairman, and all other committees or members who have contributed toward the success of this convention.

Be it further resolved that we express our thanks to the Rev. B. G. Hodge for his delivery of the invocation at the opening of this convention.

Be it resolved that we express our thanks to Judge Huston Quin for giving us such a cordial welcome to Louisville.

Be it resolved that we extend our thanks to F. A. Madge, President, for bringing us greetings from the Association of Operative Millers.

Be it resolved that we express our thanks to Dr. A. W. Homberger, of the University of Louisville for giving us such a good account of the Chemical Industries in Louisville and vicinity.

Be it further resolved that the thanks of this Association be extended to Ballard and Ballard, the United States Department of Agriculture, Station W. H. A. S., and to Standard Brands for sponsoring the radio broadcasts.

Be it resolved that the thanks of this convention be extended to Toninis' Radio Shop for furnishing the radio for our entertainment during the radio broadcasts.

Be it resolved that we extend our thanks to our past president, Leslie Olsen, for his splendid spirit and generosity in furnishing gratis the moving pictures and also the photographs of the ten past presidents of this Association.

Be it further resolved that we express our appreciation of co-operation to the American Society of Bakery Engineers and to the local section of the American Chemical Society.

Be it resolved that the thanks of this convention be extended to the Provident Chemical Works, the Central Scientific Company, the Victor Chemical Works, Standard Brands, Wallace and Tiernan, the Laboratory Construction Company, the Anheuser-Busch Company, the Southern Cotton Oil Company and the Despatch Oven Company for furnishing the golf trophies.

Be it further resolved that we express the thanks of this convention to Dr. R. C. Roark of the United States Department of Agriculture for making the special trip to Louisville to give us his description of "New Fumigants for Destroying Insect Pests in Foodstuffs."

Be it resolved that the Louisville Convention and Publicity League be extended the thanks of this Convention for supplying the young ladies, who so ably assisted with the registration of members and guests.

Be it further resolved that we express our appreciation to T. W. Vinson and the management of the Brown Hotel for their kind hospitality and the splendid manner in which they have taken care of us individually and of this convention.

F. A. Collatz moved that the resolutions be accepted. Seconded, carried.

C. B. Morison moved that the thanks of the Association be extended to L. H. Bailey for his work in drawing up these resolutions. Seconded, carried.

Report of Managing Editor

R. C. Sherwood

This report is coincident with the Secretary-Treasurer's report and will be found in Cereal Chemistry, **8**: 175-178.

Moved by R. C. Sherwood that the report be accepted. Seconded, carried.

Miscellaneous Business

A short report on the work of the Committee on Standardization of Laboratory Baking was given by H. E. Weaver. Moved by H. E. Weaver that the report be accepted. Seconded and after a few remarks by M. A. Gray, R. W. Mitchell, Mary M. Brooke, F. A. Collatz, R. J. Clark and W. F. Geddes on the advisability of more publicity the motion was carried.

Emily Grewe, chairman of the Program Committee, gave a few remarks on the work of her committee during the year.

F. L. Dunlap gave a few remarks on the work of the Committee of Milling Chemistry at Julius Rosenwald Museum of Science and Industry.

F. A. Collatz moved that the report of the Committee on Methods of Analysis be accepted. Seconded, carried.

A rising vote of thanks was given J. A. Dunn for his work as Convention Peptizer in conducting the singing that preceded each session of the Convention.

P. E. Minton moved, "That every member of the Association be mailed a new membership list each year without any obligations if he so requests it." Seconded and after a few remarks, the motion was lost when voted upon.

A. W. Meyer suggested that the Association conduct some work on rye and whole wheat flour during the year.

The Executive Committee's opinion on the proposed amendment to Article 4 of the Constitution was reiterated as outlined in their annual report by R. K. Durham and with the consent of the proposer, M. D. Mize, the amendment was withdrawn.

The report of the Nominating Committee was read by M. A. Gray, chairman.

Election of officers:

President—R. K. Durham
Vice-President—L. D. Whiting
Secretary-Treasurer—M. D. Mize
Editor-in-Chief Cereal Chemistry—D. A. Coleman
Managing Editor Cereal Chemistry—C. C. Fifield

An invitation to hold the 1933 Annual Convention in Toronto, Canada, was presented by J. A. Dunn. H. D. Liggitt extended an invitation to the Association to again hold an Annual Convention in Denver whenever it was convenient. P. E. Minton presented an invitation to hold the 1933 Convention in Chicago. G. L. Alexander delivered an invitation to the Association to hold the 1932 Convention in Detroit.

The meeting was then placed in charge of T. A. Sanford.

Paper—"Relation of Quality in Dry Skim Milk to Baking Strength" by Oscar Skovholt and C. H. Bailey, read by Washington Platt.

Paper—"The Heat of Hydration of Wheat Flour and Certain Starches Including Wheat, Rice, and Potato" by C. A. Winkler and W. F. Geddes.

R. K. Durham moved that the secretary-treasurer be given one hundred dollars as a partial appreciation of the work done during the past year. Seconded, carried.

Mr. Edward Price, member of the American Society of Bakery Engineers, was introduced and gave a few remarks.

Meeting adjourned at 12:00 noon.

Meeting called to order by President Harrel at 1:30 p. m.

A message of greeting from Ross E. Anderson, president American Society of Bakery Engineers, was read.

The meeting was then placed in charge of Victor E. Marx, secretary-treasurer of the American Society of Bakery Engineers, and devoted to a joint session with the Engineers.

Paper—"The Purchase of Flour for Bakeries" by F. B. Evers of Nashville, Tenn., read by Edward Price. A discussion was led by Gerald Billings of New York.

Paper—"Storage and Handling of Flour in the Bakery" by Oscar J. Roth of Newport, Ky.

Paper—"Mixing of Doughs with Special Reference to Flour" by John Greer of Knoxville, Tenn.

Paper—"The Composition of Bread" by C. B. Morison.

W. F. Geddes moved that a vote of thanks from the Association be extended to Dr. C. H. Bailey for his years of service with Cereal Chemistry. Seconded, carried unanimously.

G. L. Alexander moved that R. C. Sherwood be given a vote of thanks from the Association for his work with Cereal Chemistry. Seconded, carried unanimously.

Paper—"Experiences and Possibilities of a New Mechanical Method of Flour Testing and Mill Control" by C. W. Brabender.

Meeting adjourned at 5:00 p. m.

Meeting called to order at 9:10 a. m. by President Durham.

A. W. Meyer was then placed in charge.

Paper—"The Use of Certain Constituents in Bread Making with Particular Reference to the Problem of Staling" by L. H. Bailey.

Paper—"Evaluating New Wheat Varieties by Use of the Baking Test" by C. E. Mangels.

Paper—"Some Problems in Evaluating Wheat Varieties" by C. O. Swanson, read by R. J. Clark.

C. E. Mangels moved that all discussion be postponed until the end of the morning program. Seconded, carried.

Paper—"Some Relationships Involving Crumb Texture and Color" by A. E. Treloar, R. C. Sherwood and C. H. Bailey.

Paper—"The Cooking of Cereal Porridges" by N. T. Cunningham.

Paper—"Chemical Leavening Agents and Their Characteristic Action in Dough" by R. A. Barackman.

Paper—"A Simple Method for Determining the Original Ash Content of Self Rising Flour" by C. B. Gustafson.

Paper—"Rancidity" by H. O. Triebold.

Paper—"The Utility of the Tag-Heppenstall Moisture Meter on Ground Wheat Samples" by W. F. Geddes.

Meeting adjourned at 12:15 p. m.

Meeting called to order 1:30 p. m. by President Durham.

Paul Logue was placed in charge of the meeting.

Paper—"Food Requirements of Yeast" by G. S. Bratton.

Paper—"The Determination of Diastatic Enzymes of Flour" by S. Jozsa and H. C. Gore.

Paper—"A Study of the Hydrolysis of Starch in Flour and Bread by Plant Amylases" by A. Schultz and Q. Landis, read by H. C. Gore.

Paper—"A Review of Patents and the Application Thereof Involving Irradiated Cereal Products" by E. S. Stateler.

Review of E. D. Simon's book, "The Physical Science of Milling" by Bert D. Ingels.

President Durham appointed the following standing committees for the year.

Executive Committee

L. D. Whiting, Chairman	C. G. Harrel
M. A. Gray	Mary Brooke

Membership Committee

L. E. Leatherock, Chairman	A. D. Wilhoit
Wm. R. Green	W. A. Richards
C. O. Oppen	F. W. Albro
Bert Ingels	Geo. H. Buford

Committee on Methods of Analysis

C. E. Mangels, Chairman	A. E. Treloar
John T. Flohil	A. W. Meyer
F. A. Collatz	C. F. Davis

Committee on Standardization of Laboratory Baking

D. A. Coleman, Chairman	R. K. Larmour
M. J. Blish	C. O. Swanson
C. H. Bailey	R. T. Bohn
W. F. Geddes	C. N. Frey

Committee on Methods of Testing Cake and Biscuit Flours

Mary Brooke, Chairman	J. A. Dunn
Geo. L. Alexander	R. T. Bohn
L. H. Bailey	J. W. Montzheimer
C. B. Kress	L. D. Whiting
L. E. Jackson	C. H. MacIntosh
E. E. Smith	Pearl Brown

Committee on Employment

C. B. Morison, Chairman	M. D. Mize

Committee on Publicity

C. G. Harrel, Chairman

Committee on Osborne Medal Award

H. A. Weaver, Chairman	M. A. Gray
C. L. Alsberg	C. J. Patterson
C. O. Swanson	

History Committee

(Will be announced in the News Letter)

Committee of Milling Chemistry at Julius Rosenwald Museum of Science and Industry

F. L. Dunlap, Chairman	H. E. Weaver
C. B. Morison	

Convention Program Committee

(Will be announced in the News Letter)

Convention Peptizer

J. A. Dunn

Convention adjourned by President R. K. Durham.

REGISTRATION AT CONVENTION, LOUISVILLE, KENTUCKY
MAY 18 - 21, 1931

Members

Howard Adler, Victor Chemical Works, Chicago Heights, Ill.
G. L. Alexander, Commercial Milling Co., Detroit, Michigan.
A. W. Allred, Amber Milling Co., Rush City, Minn.
Lowell Armstrong, Ballard & Ballard Co., Louisville, Ky.
L. H. Bailey, Bureau of Chemistry & Soils, U. S. Dept. of Agri., Washington, D. C.
A. J. Banks, Ogilvie Flour Mills Co., Montreal, Can.
John C. Baker, Wallace & Tiernan, Newark, N. J.
R. A. Barackman, Victor Chemical Works, Chicago, Ill.
E. G. Bayfield, Ohio Agricultural Station, Wooster, Ohio.
I. A. Berg, 776 E. Ridgeway Ave., Cincinnati, Ohio.
Gerald Billings, Bakers Service Bureau, New York, N. Y.
R. T. Bohn, Great Atlantic & Pacific Tea Co., Detroit, Mich.
J. A. Bourne, Junge Baking Co., Joplin, Mo.
D. L. Boyer, Provident Chemical Works, St. Louis, Mo.
C. W. Brabender, Brabender Electrical Works, Duisberg, Germany.
G. S. Bratton, Anheuser-Busch Co., Webster Groves, Mo.
Mary Minton Brooke, Purity Bakeries Corp., Chicago, Ill.
Pearl Brown, Perfection Biscuit Co., Fort Wayne, Ind.
Lionel G. Brown, Noblesville Milling Co., Noblesville, Ind.
W. E. Brownlee, United Mills Co., Inc., Grafton, Ohio.
Howard A. Clark, Standard Brands, New York, N. Y.
Rowland J. Clark, Schulze Baking Co., Kansas City, Mo.
D. A. Coleman, Bureau of Agricultural Economics, U. S. Dept. of Agr., Washington, D. C.
F. A. Collatz, General Mills, Inc., Minneapolis, Minn.
Newton T. Cunningham, Ralston Purina Co., St. Louis, Mo.
R. K. Durham, Rodney Milling Co., Kansas City, Mo.
J. R. Davies, Calumet Baking Powder Co., Chicago, Ill.
J. A. Dunn, Novadel Agene, Ltd., Toronto, Canada.
F. L. Dunlap, Wallace & Tiernan, Chicago, Ill.
Rudy S. Edel, Bay State Milling Co., Winona, Minn.
W. G. Epstein, B. A. Eckhart Milling Co., Chicago, Ill.
G. E. Findley, Morten Milling Co., Dallas, Texas.
V. E. Fisher, Stanard Tilton Milling Co., Alton, Ill.
Henry Flick, Washburn Crosby Co., Inc., Louisville, Ky.
J. T. Flohil, Pillsbury Flour Mills, Minneapolis, Minn.
E. N. Frank, International Milling Co., Minneapolis, Minn.
L. H. Fratzke, Western Flour Mills, Davenport, Ia.
J. Freilich, Standard Brands, Inc., New York, N. Y.
Geo. Garnatz, The Kroger Grocery & Baking Co., Cincinnati, Ohio.
W. F. Geddes, Chemistry Dept., Univ. of Manitoba, Winnipeg, Man., Canada.
H. C. Gore, Standard Brands, Inc., New York, N. Y.
John Godston, The Nulomoline Co., New York, N. Y.
M. A. Gray, Pillsbury Flour Mills Co., Minneapolis, Minn.
Emily Grewe, Dept. of Agriculture, Washington, D. C.
C. B. Gustafson, Purdue University, Lafayette, Ind.
S. T. Hadley, University of Manitoba, Winnipeg, Man., Can.
Harold Hall, J. R. Short Milling Co., Chicago, Ill.
A. J. Hammer, Quaker Oats Co., Cedar Rapids, Ia.
Robert C. Harnsberger, The Page Milling Co., Luray, Va.
C. G. Harrel, Commander-Larabee Corp., Minneapolis, Minn.
W. L. Heald, Larabee Flour Mills, Kansas City, Mo.
Charles J. Henry, Hecker-Jones-Jewell Mlg. Co., Buffalo, N. Y.
Irwin Hoener, Ralston Purina Company, St. Louis, Mo.
John P. Holt, Crete Mill & Elev. Co., Crete, Nebr.
Geo. E. Howe, Lyon & Greenleaf Co., Inc., Ligonier, Ind.
Bert D. Ingels, Wallace & Tiernan Co., Inc., East Orange, N. J.
J. P. Ioannu, Penn. Salt Milling Co., Philadelphia, Pa.
L. E. Jackson, Victor Chemical Works, Chicago, Ill.
Joseph H. Julicher, Pillsbury Flour Mills Co., Buffalo, N. Y.
Walter P. Konrad, Provident Chemical Works, St. Louis, Mo.
H. R. Kraybill, Purdue University, Lafayette, Ind.
J. C. Lankenau, Loose Wiles Biscuit Co., Flushing, L. I.
S. J. Lawellin, Wallace & Tiernan Co., Inc., New Ulm, Minn.
L. E. Leatherock, Kansas Milling Co., Wichita, Kansas.
H. D. Liggitt, Jr., Colorado Milling & Elevator, Denver, Colo.
Paul Logue, The Swann Corp., Birmingham, Ala.
J. M. Lugenbeel, Merchants Exchange of St. Louis, St. Louis, Mo.
Fred J. Lumsden, King Midas Mill Co., Minneapolis, Minn.
C. H. MacIntosh, C. J. Patterson Corp., Kansas City, Mo.
Alan MacLeod, Canadian Wheat Pool, Winnipeg, Man., Canada.
C. E. Mangels, State College Sta., Fargo, N. Dak.
Jas. E. Mastin, Sovex Co., Inc., New York, N. Y.
Paul P. Merritt, University of Nebraska, Lincoln, Nebr.
A. W. Meyer, The W. E. Long Co., Chicago, Ill.
F. Micks, United Biscuit Company of America, Chicago, Ill.
P. E. Minton, Wesson Oil & Snowdrift & Sales Co., Chicago, Ill.
R. Wallace Mitchell, American Bakery Materials Co., Menomonie, Wis.
M. D. Mize, Grain Exchange, Omaha, Nebraska.

G. Moen, General Mills, Inc., Minneapolis, Minn.
J. H. Monson, Robin Hood Mills, Ltd., Moose Jaw, Sask., Canada.
C. B. Morison, Amer. Institute of Baking, Chicago, Ill.
H. V. Moss, Provident Chemical Works, St. Louis, Mo.
C. J. Newell, Burrus Mill & Elev. Co., Fort Worth, Texas.
E. F. Olmstead, Great West Mill & Elev. Co., Amarillo, Texas.
A. G. Olsen, General Foods Corp., Battle Creek, Michigan.
Leslie R. Olsen, International Milling Co., Minneapolis, Minn.
Clarence Oppen, Lawrenceburg Roller Mills Co., Lawrenceburg, Indiana.
E. M. Paget, Rumford Chemical Works, Chicago, Ill.
L. H. Patten, Jr., State Mill & Elev., Grand Forks, N. Dak.
F. D. Patterson, Texas Star Flour Mills, Galveston, Texas.
Earl C. Paulsel, International Milling Co., Minneapolis, Minn.
P. R. Pitts, Red Band Co., Johnson City, Tenn.
Washington Platt, The Borden Co., Syracuse, N. Y.
R. B. Potts, Wichita Flour Mills Co., Wichita, Kans.
A. F. G. Raikes, The Northwestern Miller, St. Louis, Mo.
O. H. Raschke, Victor Chemical Works, La Grange, Ill.
Roland Reid, Allied Mills, Inc., St. Louis, Ill.
W. A. Richards, International Milling Co., Buffalo, N. Y.
O. G. Salb, Blish Milling Co., Seymour, Ind.
R. M. Sandstedt, Univ. of Nebraska, Lincoln, Nebr.
Thos. W. Sanford, Eagle Roller Mill Co., New Ulm, Minn.
R. C. Sherwood, General Mills, Inc., Minneapolis, Minn.
V. Shiple, National Milling Co., Toledo, Ohio.
Elise C. Shover, American Bakeries Co., Atlanta, Ga.
Wm. Siedhoff, E. E. Werner, St. Louis, Mo.
Edw. E. Smith, F. W. Stock & Sons, Hillsdale, Mich.
E. S. Stateler, Food Industries, New York, N. Y.
W. E. Stokes, Royal Baking Powder Co., Brooklyn, N. Y.
Betty Sullivan, Russell Miller Inc., Minneapolis, Minn.
L. M. Thomas, The Mid-West Laboratories Co., Columbus, Ohio.
Howard O. Triebold, Penn. State College, State College, Pa.
E. Rex Uphouse, Commonwealth Flour Mills, St. Louis, Mo.
C. G. Vaupel, Chickasha Milling Co., Chickasha, Okla.
James D. Veron, Anheuser-Busch, Inc., St. Louis, Mo.
H. G. Walter, Igleheart Bros., Inc., Evansville, Ind.
H. E. Weaver, Kansas Flour Mills Corp., Kansas City, Mo.
L. D. Whiting, Ballard & Ballard Co., Louisville, Ky.
A. K. Whittaker, David Stott Flour Mills, Detroit, Mich.
Adolph Wiesehahn, Black Bros. Flour Mills, Beatrice, Nebr.
Harry W. Winkler, Pinnacle Mills, Inc., Morristown, Tenn.
J. C. Wood, The Merchants Co., Laurel, Miss.
W. B. Young, State of Minn. Grain Lab., Minneapolis, Minn.

Visitors and Guests

Fred T. Ballard, Louisville Herald-Post, Louisville, Ky.
Newton Evans, National Miller and American Miller, Chicago, Ill.
Roy W. Hanson, 3921 16th Ave. So., Minneapolis, Minn.
F. H. Faber, Despatch Oven Co., Minneapolis, Minn.
Chas. A. Glabau, Bakers Weekly, New York, N. Y.
John L. Greer, Brown, Greer & Co., Knoxville, Tenn.
Arthur Hartkopf, Brabender Machine Corp., New York, N. Y.
J. L. Henderson, C. J. Tagliabue Mfg. Corp., Brooklyn, N. Y.
Elizabeth McKim, Provident Chemical Wks., St. Louis, Mo.
Frank A. Madge, Noblesville Mlg. Co., Noblesville, Indiana.
Victor E. Marx, Bakers' Helper, Chicago, Ill.
Nellie Meffert, Ballard & Ballard Co., Louisville, Ky.
Robt. Morrison, The Page Milling Co., Luray, Va.
Jessie Nichols, Ballard & Ballard Co., Louisville, Ky.
R. A. Pouchain, Tasty Baking Co., Philadelphia, Pa.
R. C. Roark, Bureau of Chemistry & Soils, U. S. Dept. of Agr., Washington, D. C.
O. B. Winter, Mich. State College, Exp. Sta., E. Lansing, Mich.

Mrs. A. W. Allred, Rush City, Minn.
Mrs. L. Armstrong Louisville, Ky.
Mrs. Lionel G. Brown, Noblesville, Ind.
Mrs. Henry Flick, Louisville, Ky.
Mrs. J. T. Flohil, Minneapolis, Minn.
Mrs. E. N. Frank, Minneapolis, Minn.
Mrs. Geo. Garnatz, Cincinnati, Ohio.
Mrs. John Godston, Madison, Wis.
Mrs. M. A. Gray, Minneapolis, Minn.
Mrs. C. B. Gustafson, Lafayette, Ind.
Mrs. C. G. Harrel, Minneapolis, Minn.
Mrs. Geo. E. Howe, Ligonier, Ind.
Mrs. S. J. Lawellin, New Ulm, Minn.
Mrs. L. E. Leatherock, Wichita, Kans.
Mrs. Paul Logue, Birmingham, Ala.
Mrs. J. M. Lugenbeel, St. Louis, Mo.
Mrs. R. Wallace Mitchell, Menomonie, Wis.
Mrs. G. Moen, Minneapolis, Minn.
Mrs. Leslie R. Olsen, Minneapolis, Minn.
Mrs. L. H. Patten, Jr., Grand Forks, N. D.
Mrs. Earl C. Paulsel, Minneapolis, Minn.
Mrs. R. B. Potts, Wichita, Kans.
Mrs. R. A. Pouchain, Philadelphia, Pa.
Mrs. O. H. Raschke, La Grange, Ill.
Mrs. Myrtle Richards, Buffalo, N. Y.
Mrs. O. G. Salb, Seymour, Ind.
Mrs. Thos. W. Sanford, New Ulm, Minn.
Mrs. R. C. Sherwood, St. Paul, Minn.
Mrs. E. E. Smith, Hillsdale, Mich.
Mrs. L. M. Thomas, Columbus, Ohio
Mrs. C. G. Vaupel, Chickasha, Okla.
Mrs. H. E. Weaver, Kansas City, Mo.
Mrs. L. D. Whiting, Louisville, Ky.
Mrs. O. B. Winter, East Lansing, Mich.

Message of the President [1]

C. G. HARREL

Friends of my radio audience, the membership of this Association is composed of prominent cereal chemists from every state in the Union and the District of Columbia. Chemists and other scientists from England, Germany, France, Scotland, Roumania, South America, Canada, Switzerland, Czecho-Slovakia, Australia, Holland and Belgium are also to be found upon its roster of membership.

We learn from the Bible that Abraham told Sarah to prepare fine meal for the angels. Grinding or milling was even then an old art and belonged to woman's daily work. It is evident that Sarah used a sieve to obtain the fine meal, for we know from historical records that the finer meal was used for the rich and the elect, while the coarser meal was given to the slaves. We also find that the ancient Mosaic law forbade anyone taking a mill-stone in pledge of a debt, which shows the importance placed upon the grinding of wheat for use by the people in days when subsistence was the problem.

Bread is probably the oldest prepared food known to history. Its origin is shrouded in the mists of unrecorded time; yet loaves of bread are the only foods that have survived intact, in the hidden stores of centuries, all others falling prey to the decay that eliminates any survival of evidence of what they were.

By your own firesides, you have heard talented speakers and master reporters like Floyd Gibbons with spell-binding words describe the magical achievements of science in the electrical and mechanical industries. It is a far cry from the lowly hearth of the bake oven to the complex machinery of our electrical and mechanical industries. Yet science has kept the wheat-growing, milling and baking business, in step with modern developments.

So long have the agricultural, milling and baking industries been known, that it is difficult to portray them in their present state of perfection. A quarter of a century ago, these industries summoned to their side the chemist. Sixteen years ago, in order that cooperative work might be facilitated, the American Association of Cereal Chemists was organized. Forty university and college professors, together with some four hundred graduate chem-

[1] A message from C. G. Harrel, President of the American Association of Cereal Chemists, delivered by C. C. Fifield, Baking technologist and and milling specialist in the Bureau of Plant Industry, U.S.D.A., through WRC and 42 other radio stations associated with the National Broadcasting Company, Monday, May 18, 1931, at 12:54 p.m., Eastern Standard Time.

ists, daily direct the control and research work culminating in the products, bread, cake and pastry. Shoulder to shoulder, these trained scientists are working with the farmer, miller and baker.

In cooperation with the departments of our universities, the cereal chemists have materially assisted in developing new varieties of wheat of better yielding power, more highly resistant to disease, and capable of producing better bread. In our agricultural experiment stations, methods of harvesting, storage and milling are being studied. Together with the millers, these scientists are daily working. Cautiously they survey the wheat fields and pick those wheats best suited for each type of flour. By this close selection, flours particularly suited for bread, crackers, and cakes are obtained. Methods of milling and ageing flours are carefully investigated. The flour now passes into bake-shops where the bakers together with the chemists, rigidly inspect all ingredients that go into the bakery products. The fermentation of the doughs is carefully governed to produce attractive products with an appealing flavor. Even to the time these finished products reach your door, they are under careful scientific scrutiny.

Thus, you observe, a loaf of bread has a staff of scientific experts supervising its manufacture as do many other products of our most modern industries.

The cereal chemists of America have pledged their Association, and devote their lives, to the improvement of the oldest and one of our best foods. This pledge and devotion of their energies is your assurance of uniformity and high quality.